REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON AVIATION SAFETY FEBRUARY 1997

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR
ACQUISITION AND TECHNOLOGY

WASHINGTON, D.C. 20301-3140

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DEFENSE SCIENCE
BOARD

3 May 97

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (A&T)

SUBJECT: Defense Science Board Aviation Safety Task Force Report

Enclosed is the final report of the Defense Science Board Task Force on Aviation Safety, chaired by General Bernard (Randy) Randolph. There are 3 major recommendations and a number of supporting recommendations. These conclusions and recommendations have been briefed to the Service Chiefs with universal agreement.

I would like to echo the Task Force's feeling that:

- The Department continue to reduce aviation accidents towards an eventual goal of zero;
- Acquisition consider accidents a part of Life Cycle Cost and, using Cost Benefit Analyses and Attrition Trade Studies, acquire the accident avoidance technologies needed to build increased safety into our systems; and
- The Services continue Integrating the Operational Risk Management process within aviation planning and operations.

The recommendations of this Task Force could generate important changes in the way we go about buying and flying aircraft. I would urge you to staff this report among the Services and OSD, and then rapidly move out on the implementation actions.

Craig I. Fields
Chairman

Attachment

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DEFENSE SCIENCE
BOARD

27 Feb 97

Dr. Craig Fields
Chairman, Defense Science Board
3140 Defense Pentagon
Washington, DC 20301-3140

Dear Dr. Fields,

Enclosed is the report of our Defense Science Board Task Force on Aviation Safety. We were asked to look at methods to improve the safety of military aviation and recommend approaches and technologies to reduce the Department's annual billion dollar losses and the accompanying erosion of readiness and loss of life.

We concluded that there is a need for strong, aggressive action to meet future Aviation Safety challenges. This conclusion was developed as a result of three key factors:

1. The previously declining DoD accident rate has now reached a plateau,
2. The safety programs within the DoD have done an excellent job of correcting the immediate causes of accidents, but have addressed the basic causes only to a limited extent, and
3. The Life Cycle Cost of accidents on readiness or acquisition is rarely addressed.

Accordingly, we recommended several actions to help the Department continue making progress improving Aviation safety.

We also found that there is no "acceptable" accident rate--a single accident and/or a single loss of life is too much. Therefore, we believe the Department should develop plans to work toward a goal of zero Class A mishaps. We believe that this requires that all involved in military aviation need to recognize that safety is an integral part of mission performance. "Safety first" slogans are meaningless and counterproductive, but when safety becomes part of the mission (rather than something added on), remarkable improvements are possible--as the Army has shown. However, this activity needs senior level leadership throughout DoD. Moreover, it will require a concerted effort supported by top talent and adequate funding.

This report provides recommendations on how best to use the talent and funding. We believe our recommendations, when adopted, will better preserve the Department's ability to safely and successfully accomplish the sometimes risky tasks expected of it by our Nation.

For the DSB Task Force on Aviation Safety,

Randy Randolph
Chairman

CONTENTS

DEFENSE SCIENCE BOARD
TASK FORCE ON AVIATION SAFETY

Executive Summary

The Task Force was formed in November 1996. It met formally eight times. Three of those meetings took place at the Safety Centers of the Army, Navy (Marine) and Air Force. The objective of the study was to make recommendations regarding ways to reduce the rate of military aviation accidents, and, more importantly, to reduce the recent rise in loss of life that accompanies these avoidable events . The following specific tasks were outlined in the Terms of Reference (TOR):

TOR#1. Determine the need/value of a joint program to require a standardized process for reporting and assessing the causes of accidents,

TOR#2. Determine the effectiveness of methods presently used to disseminate lessons learned to help prevent accidents,

TOR#3. Recommend new approaches to reduce the incidence of recurring safety problems. These problems include accident causal factors such as human error and controlled flight into terrain,

TOR#4. Assess the need for a DoD-wide Human Performance network to improve the identification and dissemination of lessons learned across the Services,

TOR#5. Recommend new approaches to institutionalize risk management within the Services, and

TOR#6. Provide recommendations concerning flight safety technologies that should be installed on each type of aircraft.

Task Force members are listed below:

General Bernard P. Randolph, USAF (Ret)
Chairman
Former Commander, Air Force Systems Command
TRW Space & Electronics Group

Mr. Alan J. McLaughlin
MIT Lincoln Laboratory

Col. George R. Durham, USAF (Ret)
Former Wing Commander
Private Consultant

Dr. Alvar M. Kabe
The Aerospace Corporation

Capt. Robert G. Buley
Northwest Airlines, Inc.

VADM Robert F. Dunn, USN (Ret)
Former Deputy CNO, Air Warfare
Private Consultant

LTG Ellis D. Parker, USA (Ret)
Former Chief, Army Aviation Branch
Private Consultant

Mr. Raymond R. LaFrey
MIT Lincoln Laboratory

Dr. Gerald A. Navratil
Columbia University

Please note that the Task Force membership included a cross section of representation from the aviation community - the airlines, universities, military Services, industry and FAA consultants.

The Task Force discovered that the Services have made impressive improvements in aviation safety. Accident rates (i.e., major mishaps per 100,000 flight hours) have continued to decline over the past twenty years. Unfortunately, the declining rate has leveled off - reaching something of a plateau during the last three years. Moreover, accident fatalities and aircraft destroyed continue to occur in large numbers as shown below (note that over 70% of these losses involve human error).

AVIATION LOSSES

Year	Billions of $	Lives	Aircraft Destroyed	Rate
1990	1.39	119	143	2.04
1991	1.34	138	149	2.10
1992	1.44	136	116	2.07
1993	1.61	119	111	1.94
1994	1.21	68	86	1.62
1995	1.30	89	69	1.53
1996	1.13	108	67	1.50

After reviewing the Services' safety program in depth and reviewing briefings from safety experts from a variety of disciplines, the Task Force developed the following observations and recommendations:

Observations:

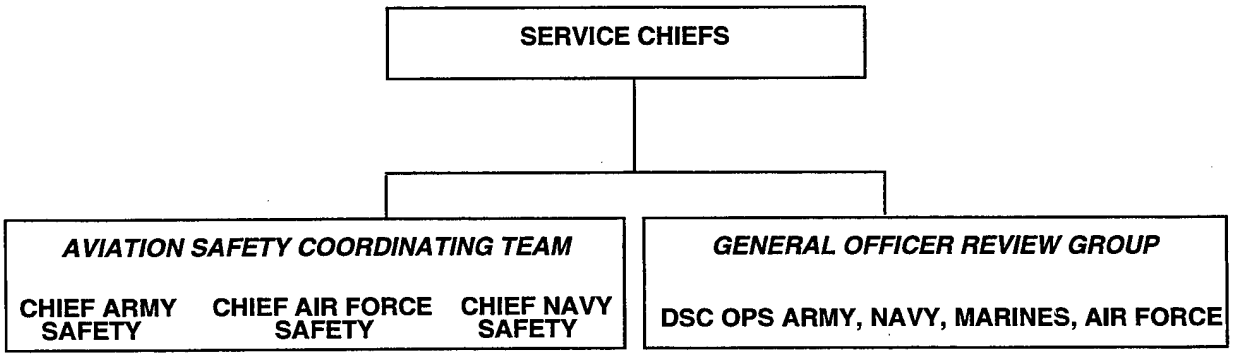
1. Safety is an integral part of Mission Success.
2. The dissemination of "lessons learned" among the Services to help prevent accidents is active and effective. The Air Force and the Navy share all accident reports immediately with the other Services. However, the Army reports are available only upon request.
3. Since Class A mishaps rates have now reached a plateau, new approaches will be required to reduce them further.
4. "Human performance" is a causal factor in over 70% of all Class A mishaps.
   - FAA, NASA, universities and industry have cooperatively designed and implemented a National Plan for Aviation Human Factors. Department of Defense participation in this effort has been sporadic.

5. Flight data recorders provide new opportunities to collect performance and maintenance data.
   - Savings in life cycle costs can be achieved by using maintenance data recorders to help anticipate faults and reduce downtime.
6. The Army has developed a "Risk Management" tool to help commanders assess mission accident risk. The tool not only helps identify hazards but also suggests effective controls. The tool has been used successfully in a number of key recent missions, beginning with Bosnia.
7. The Service Safety Centers are doing an excellent job of addressing the "immediate" causes of mishaps. However, there is not sufficient effort being placed on identifying, understanding, and correcting the "root" causes. The latter effort is essential to achieving a goal of zero mishaps.
8. The use of on-board equipment such as GPS receivers and health/usage monitoring equipment and other safety equipment now carried by civil transport aircraft provide significant new tools/capabilities for mishap prevention.
   Note: The above observations are discussed in greater detail in the report text.
9. With regard to installing the safety equipment mandated by SecDef in April, 1996, all of the Services appear to face funding difficulties.

Recommendations:

(The Task Force recommendations include offices for implementation with dates for completion. Obviously these are made from the Task Force perspective and are suggestions only).

1. Recognize Service Chiefs as their respective Service's Aviation Safety Advocates and have the Joint Chiefs periodically assess and discuss the status of Aviation Safety. At least annually, they should brief the Secretary of Defense on their assessment of the Department's overall Aviation Safety performance, including the readiness and cost impacts of accidents. Establish the reporting structure outlined below:



Action: Sec of Defense
Date: May 1997

2. Establish a DoD Budget for the design, development test and deployment of new aviation safety equipment (hardware/software) processes, and research. Allocate $50M in FY97, $100M in FY98 and $200M each year thereafter in the FYDP. These funds will be apportioned to the Services by the General Officer Review Group based on the recommendations of the Service Safety Chiefs. (The funding will be identified in each of the Service budgets and administered by the Service.) The Aviation Safety Team Organization will coordinate activities and oversee the use of the funds.
   Action: Deputy Sec of Defense
   Date: May 1997

3. Develop a joint mishap information architecture to include standardized electronic reporting capability. (All mishap reports should be shared automatically among the Services.)
   Action: Aviation Safety Coordinating Team
   Date: Report results to Vice Chairman by June 1997

4. Establish measurable intermediate milestones to work toward a goal of zero Class A aviation mishaps within DoD.
   Action: Deputy Sec. Of Defense
   Date: Immediately

5. Develop a plan to exploit the new opportunities afforded by flight data recorders to collect flight crew performance and maintenance data (develop a joint information architecture.)
   Action: Service Chiefs
   Date: September 1997

6. Establish a joint risk management team within the joint staff to institutionalize risk management and safety planning.
   Action: Chairman JCS
   Date: April 1997

7. Institutionalize "Risk Management" tools, techniques, and procedures throughout the Services.
   Action: Army, Navy/Marine, AF, DCS/Operations Team
   Date: December 1997

8. Assure that an assignment as an operational safety officer is a significant step for career development and promotion.
   Action: Vice Chiefs of the Army, Navy/Marine, AF
   Date: Report results to Vice Chairman in June 1997

9. Establish and fund a comprehensive research program on human performance capitalizing on and coordinating with other government agencies. Coordinate with other Government and Civil agencies (e.g., NASA and the FAA) and become more active in any of their efforts that may benefit the safety of military aviation.

   Action: USD(A&T)

   Date: September 1997

10. Budget the funds necessary to install high priority flight safety equipment in military aircraft., including bringing DoD passenger aircraft up to FAA standards
    Action: Sec. Defense
    Date: March 1997

11. Monitor the progress of the Services with regard to installation flight safety equipment in military aircraft., assuring that transport aircraft meet FAA civil transport requirements
    Action: Vice Chairman, JCS
    Date: Quarterly

12 The Services should apply the results of safety-related Life Cycle Cost studies on all new aircraft as well as those undergoing major modifications. Cost Benefit Analyses and Attrition Trade Study results should assist in decisions regarding the installation of flight safety equipment in military aircraft.
    Action: Under Secretary of Defense (A&T)/DAB/Program Managers, JCS
    Date: September 1997

13. Reallocate funds to support necessary safety improvements.
    Action: Under Secretary of Defense (A&T)
    Date: September 1997

Introduction

- Congress directed DoD to accomplish a study to address aviation safety issues
  - Report findings no later than 31 March 97
- USD (A&T) directed the DSB to form a task force to accomplish the study
- Task Force was formed in November 96
- Directed by USD (A&T) to complete report by 28 Feb 97
- The group met eight times
- Three meetings took place at the Service Safety Centers

1

Task Force Members

General Bernard P. Randolph, USAF (Ret) Chairman
Former Commander, Air Force Systems Command
TRW Space & Electronics Group

LTG Ellis D. Parker, USA (Ret)
Former Chief, Army Aviation Branch
Private Consultant

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Task Force Members

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The Aerospace Corporation

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MIT Lincoln Laboratory

Mr. Alan J. McLaughlin
MIT Lincoln Laboratory

Dr. Gerald A. Navratil
Columbia University

3

Terms of Reference

- Task requested by Congress
  - Determine the need/value of a joint program to require a standardized process for reporting and assessing the causes of accidents
  - Determine the effectiveness of methods presently used to disseminate lessons learned to help prevent accidents
  - Recommend new approaches to reduce the incidence of recurring safety problems. These problems include accident causal factors such as human error and controlled flight into terrain

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Terms of Reference
(continued)

DSB Aviation Safety Task Force

- Tasks requested by the Services/OSD
  - Assess the need for a DoD-wide Human Performance network to improve the identification and dissemination of lessons learned across the Services
  - Recommend new approaches to institutionalize risk management within the Services
  - Provide recommendations concerning flight safety technologies that should be installed on each type of aircraft

5

DSB Task Force Results

- Study completed on schedule
  - USD (A&T) was briefed on 27 Feb 97
- Briefings also provided to:
  - DUSD (Environmental Security)
  - Director, Defense Science Board Secretariat
  - Vice Chair, JCS
  - USD (P&R)
- Report to Congress in final preparation
  - Briefing will be provided on request

6

Aviation Losses

Year	Billions of $	Lives	Aircraft Destroyed	Rate
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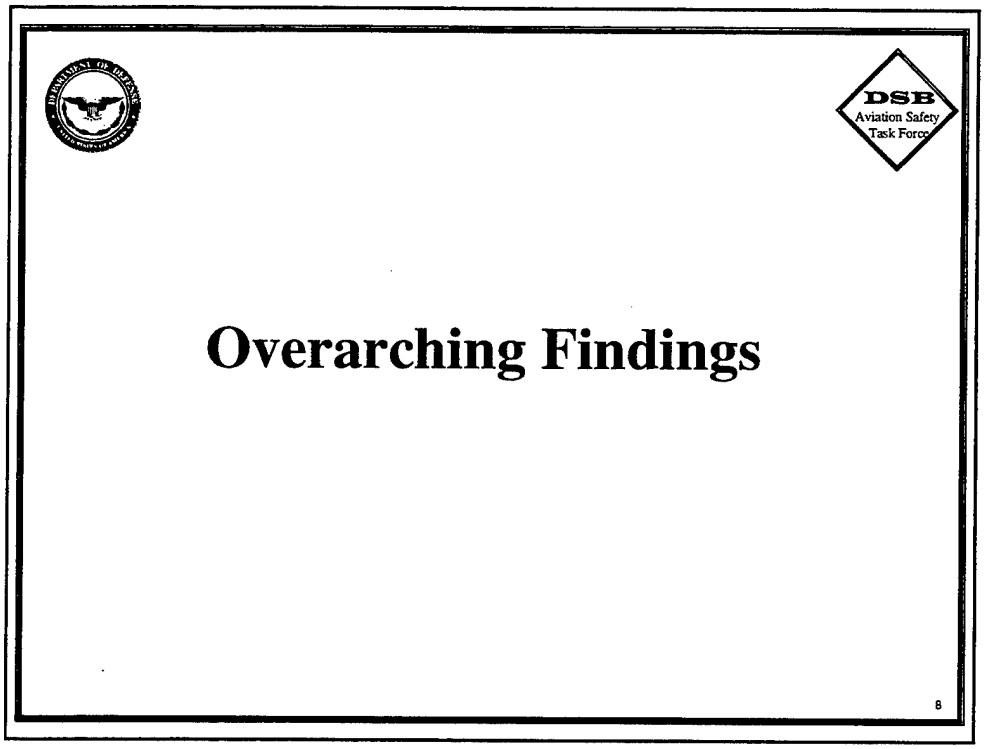
DSB
Aviation Safety
Task Force
Overarching Findings
8

Overarching Findings

Leadership

- **Finding I:**
  - Safety is an integral part of Mission Performance
  - Leadership is the single most important factor affecting aviation safety; Commanders at every level must be personally involved
- **Recommendation:**
  - Review the role of leadership/command in aviation safety
    - Include training

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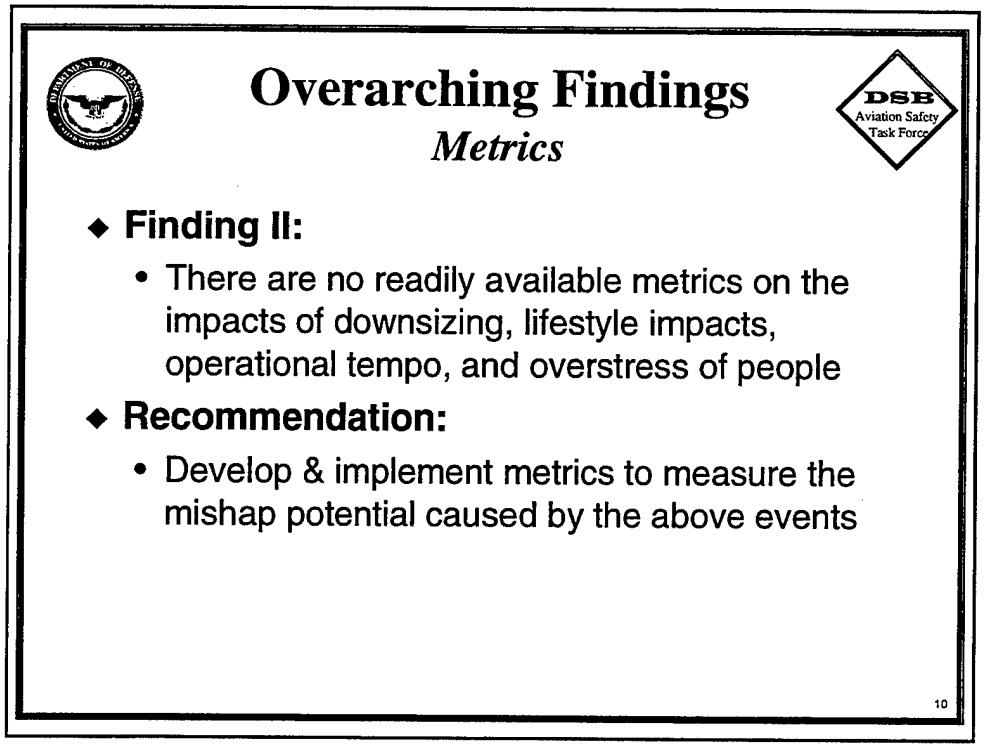

Develop a metric to measure stressors (such as downsizing, lifestyle changes, and increased operational tempo) and their influences on unit safety. The unit commander can then increase efforts to manage and reduce stress on people, such as a down day where flight operations are ceased. This includes considering impacts on individual performance that could result from lifestyle changes, such as a divorce, or an event affecting career plans.

It would also be useful if Risk Management systems incorporated tools which considered stress level.

Overarching Findings

Policy

- **Finding III:**
  - Inconsistencies exist between DoD aircraft used for passenger and troop transport and civil aircraft leased for similar purposes
- **Recommendation:**
  - Develop a policy for military transport aircraft which requires the same safety equipment as that required on Part 121 civil transport category aircraft. Waivers to this policy would be approved at the Service Chief level

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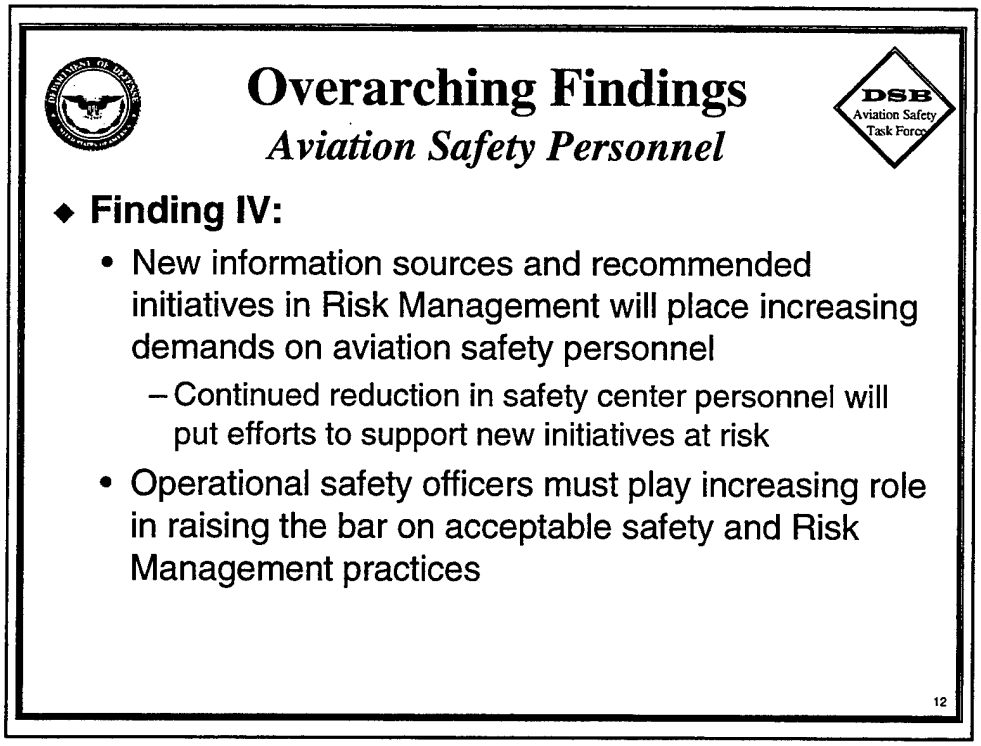

The Task Force has made a number of recommendations that when implemented will increase the Safety Centers' work loads. Initially, the Safety Centers will be required to participate in the development of a common information architecture and associated databases. Once developed, they will be required to store, maintain and analyze data, and publish reports. They are also expected to participate in the recommended "Risk Management" initiatives. It is expected that this will increase the demand on aviation safety personnel. Therefore, it is recommended that personnel levels and skill mix be reviewed and, if necessary, adjusted such that adequate staff is available to make sure that Task Force recommended initiatives can be implemented.

Overarching Findings

Aviation Safety Personnel

(continued)

DSB Aviation Safety Task Force

- **Recommendations:**
  - Initiate review of current personnel levels with specific attention to requirements to support new initiatives in Risk Management, & the processing, analysis, and dissemination of safety information
  - Make operational safety officer assignments a significant step for career development and promotion

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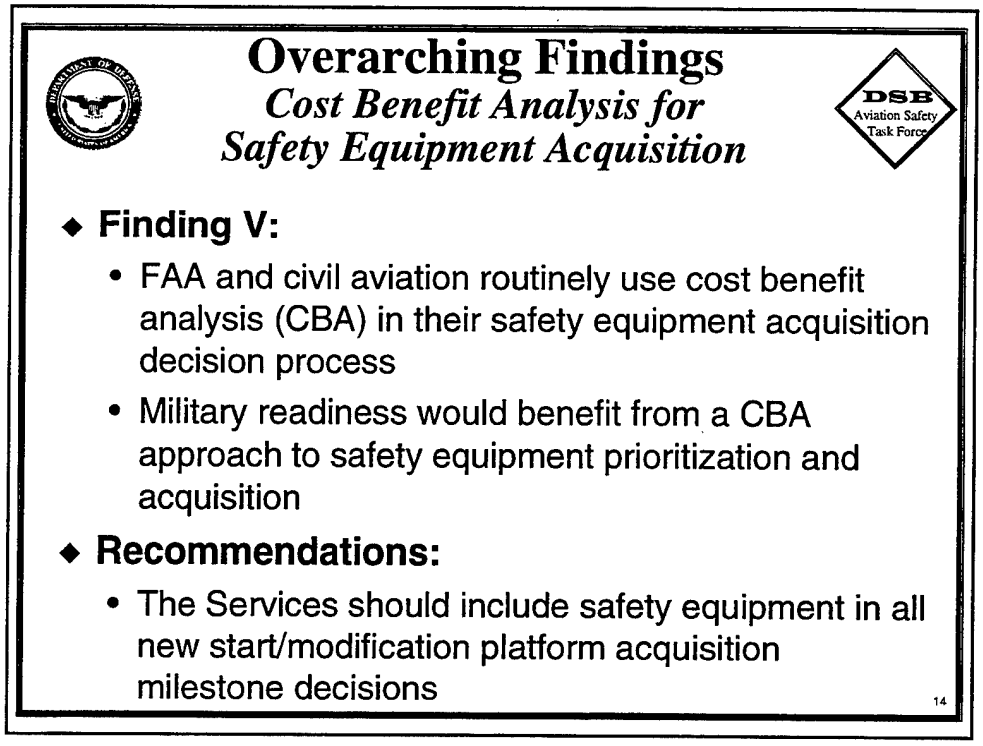

Mishap rates are very costly in terms of loss of life and loss of increasingly expensive equipment.

To understand how the DoD is addressing this issue, the Task Force considered information provided by the Service Safety Centers and current practices in the civil aviation community (airlines, general aviation, and the FAA). It appears that, because of budget procedures, military Services are not currently motivated to invest in safety technology that is likely to avoid down-stream loss of life and equipment, especially in non-combat aircraft. The emphasis has been and continues to be on equipment directly related to combat missions along with minimizing initial unit cost.

Airlines and other civil aircraft operators, as well as the FAA, use cost-benefit-analysis as a strategy for capitalizing safety equipment.

The net benefit to the Services would be to achieve a force multiplier and improve readiness through the use of a cost benefits analysis driven basis for prioritizing funding of safety equipment. Safer aviation operations would result in more trained pilots (fewer fatalities) and more planes at a readiness state (through fewer losses).

Recommendation

The Task Force recommends that the Services adopt a life cycle cost benefit analysis approach to justify and support funding decisions for safety equipment which takes into account life cycle cost savings, lower equipment replacement costs and most importantly, reduced loss of life.

TOR #1

Determine the need/value of a joint program to require a standardized process for reporting and assessing the causes of accidents

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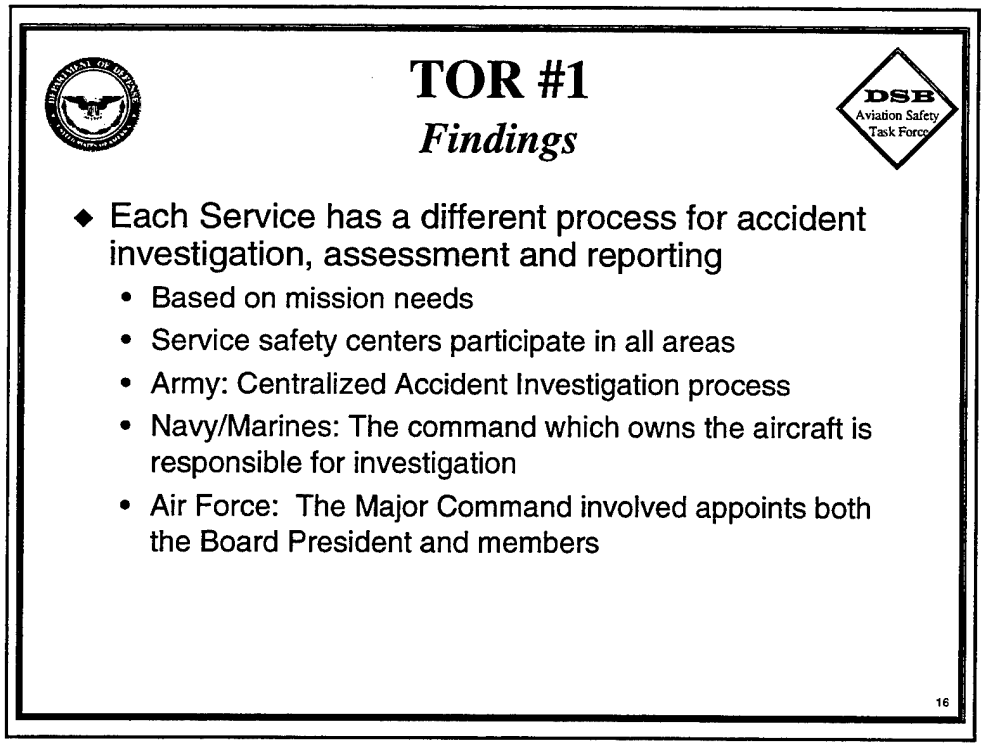
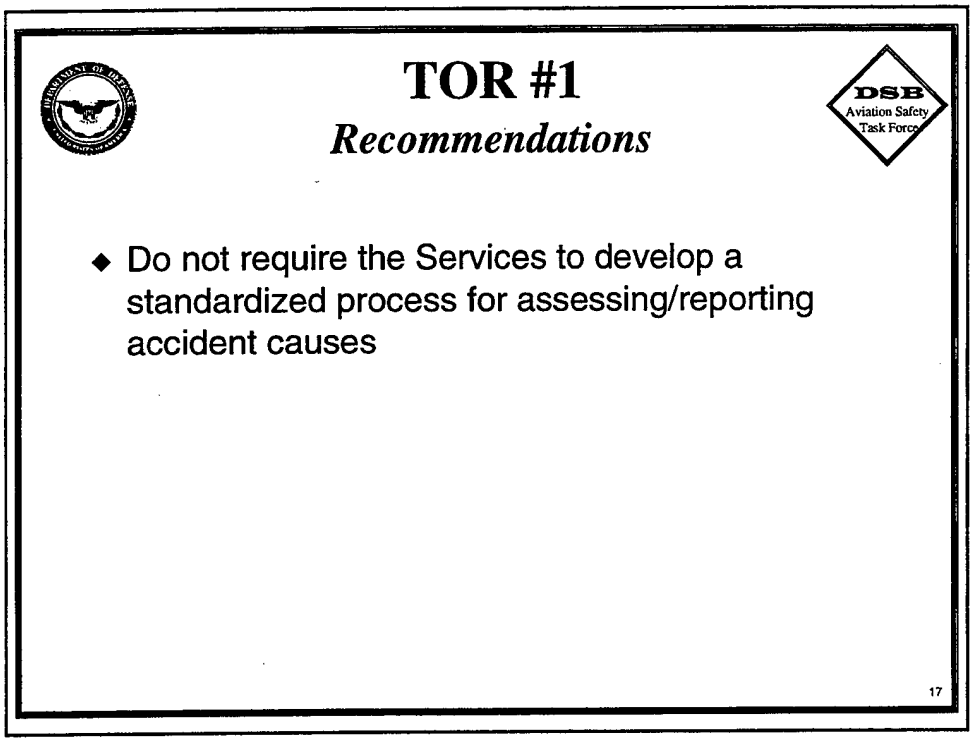
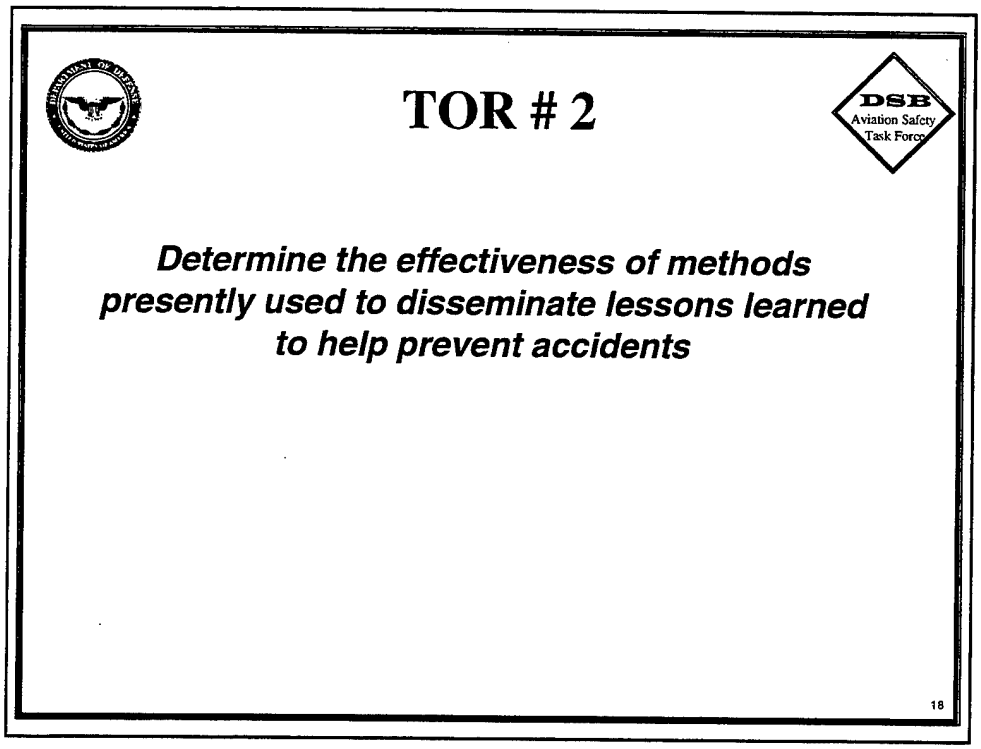


In most cases the investigation process is completed in a timely manner. The analysis and reporting is accomplished within 60 days. The Task Force was impressed with the thorough and professional approaches used by the Services. Although each Service process is different in terms of organization and administration, the fundamentals of proper accident investigation were practiced in all cases.



A standardized process for reporting could be developed among the Services. But there is no need to make such a change and the Task Force could find no particular value associated with standardization. Further, the process of developing agreed-upon standards would probably be lengthy and would detract from the important daily work of the Safety Centers.


TOR # 2
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Task Force
Determine the effectiveness of methods
presently used to disseminate lessons learned
to help prevent accidents
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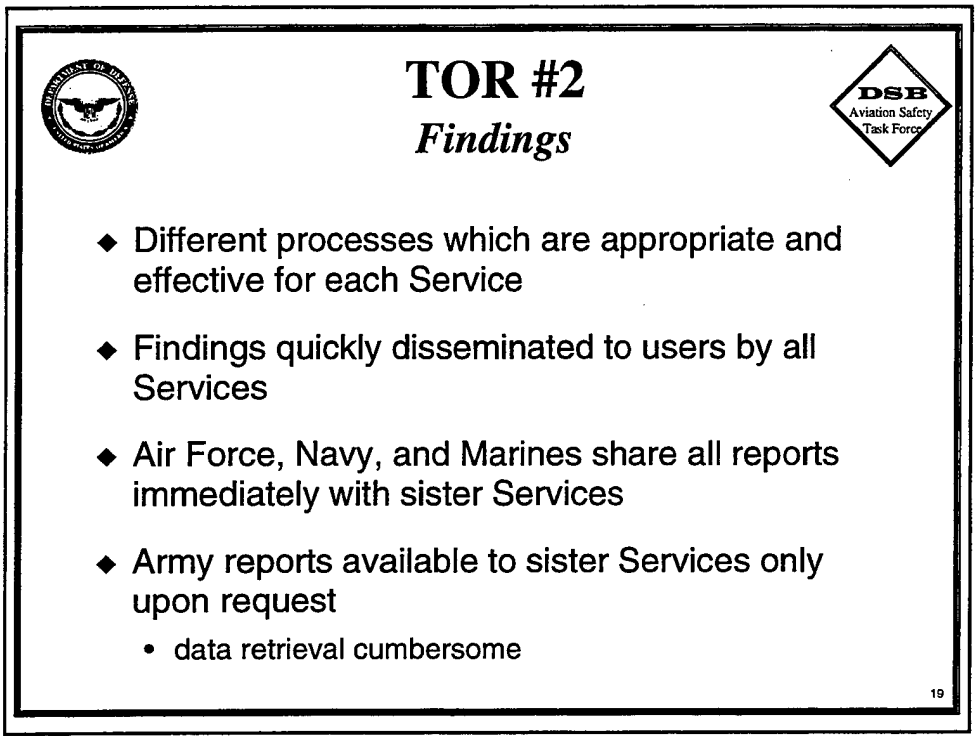
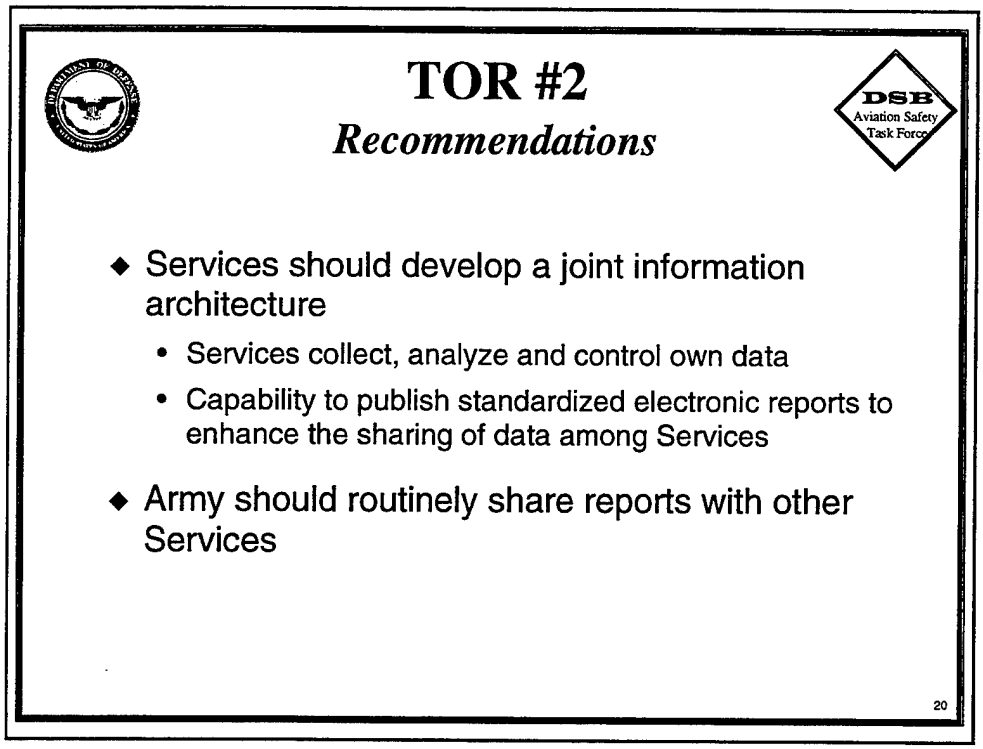


The Task Force reviewed the Services' processes for dissemination of lessons learned from accident investigation boards. Each Service has a different process. Procedures are in place to ensure that all appropriate intra-Service organizations and people are efficiently notified of important findings, whether interim or final. Formal Board findings and recommended actions are rapidly disseminated. The Air Force and the Navy/Marines share their findings immediately with the other Services by the same electronic messages that inform internal Service organizations. The Army does not disseminate findings directly to other Services, but makes the information available upon request. Army information can be obtained electronically by the sister Services; however, the system is complicated and not user friendly.

On the other hand, there is a need for standardized computer data base. The Army is working to obtain such a standard system, but currently has insufficient funds to complete the effort. The Task Force strongly recommends that a Joint Service Team be established to agree upon the best approach to a standard data system. Further, it is recommended that OSD provide the funds necessary to field the system. Such a system would allow open access (within DoD) to all Services' data when needed. This access could provide another basis for accident prevention activities.



The Task Force was impressed with the Services' sense of urgency in disseminating accident prevention information derived from Investigation Board findings. The Task Force recommends the Services jointly develop an information architecture which accommodates each Service's requirements to enhance safety information processing, storage and dissemination. Care must be exercised to develop safeguards to protect privileged information. Each Service should control its own data. The Task Force also recommends the Army routinely share information as currently practiced by the other Services. The Task Force does not feel this will compromise the confidentiality of privileged information upon which each Service uses to determine root causes of aircraft accidents.

TOR #3

Recommend new approaches to reduce the incidence of recurring safety problems. These problems include accident causal factors such as human error and controlled flight into terrain

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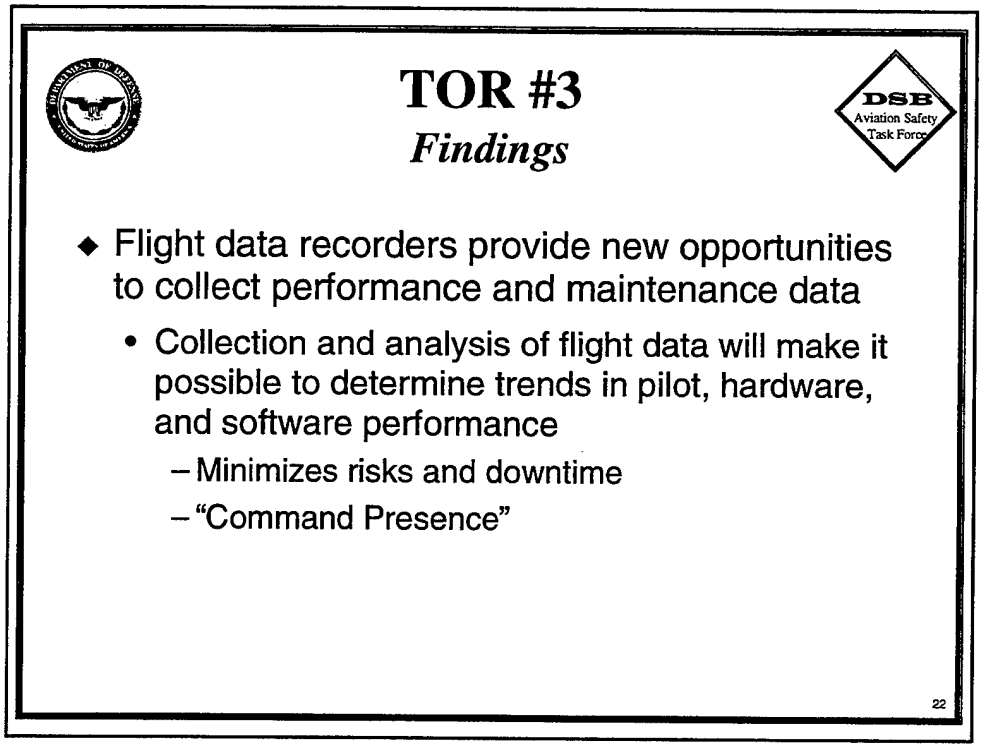
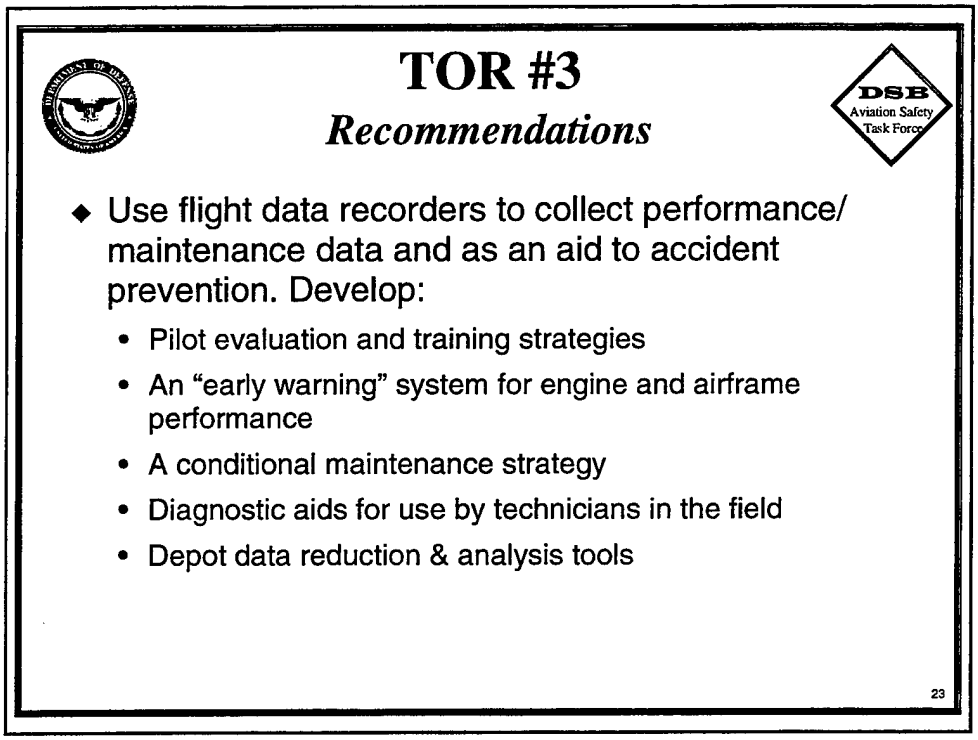


Contrary to public perception, mishap rates have declined significantly for the military Services to where they are at historical lows. The data also indicates that a plateau has been reached. The 1996 class A mishap rates for the Air Force, Army, and Navy/Marine Corps are 1.26, 0.64 and 2.3, respectively. It is the Task Force's opinion that any further, significant, reduction in these rates will require new approaches.

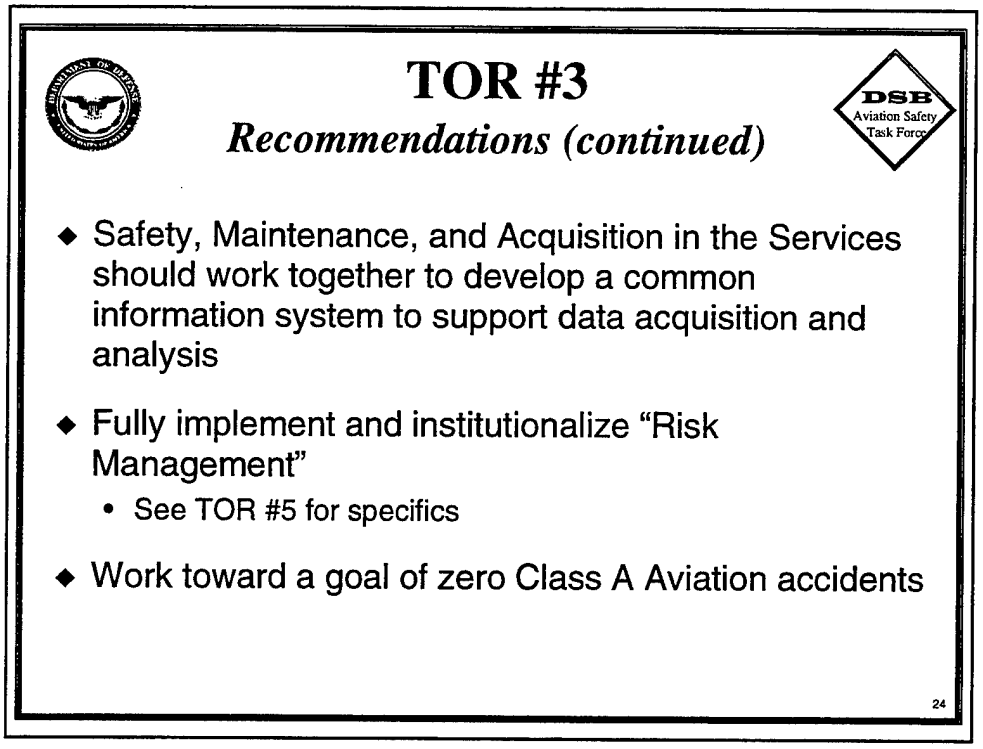
In addition to supporting accident investigations, flight data recorders (FDR) provide a significant opportunity to collect performance and maintenance data that could be used to determine trends in pilot, hardware and software performance. This data could then be used to improve training and reduce the life cycle costs of aircraft by anticipating faults, reducing downtime, and reducing the risk of mishaps.

The Task Force is of the opinion that an additional and significant benefit of flight recorders is the reduction in flight rule violations - the cause of large numbers of flight mishaps. Flight recorders provide a form of "Command Presence" which, experience indicates, reduces violations.

The airline industry is experienced in obtaining, analyzing and using flight data for performance monitoring and maintenance. The opportunity, therefore, exists to leverage commercial flight safety and information technologies.

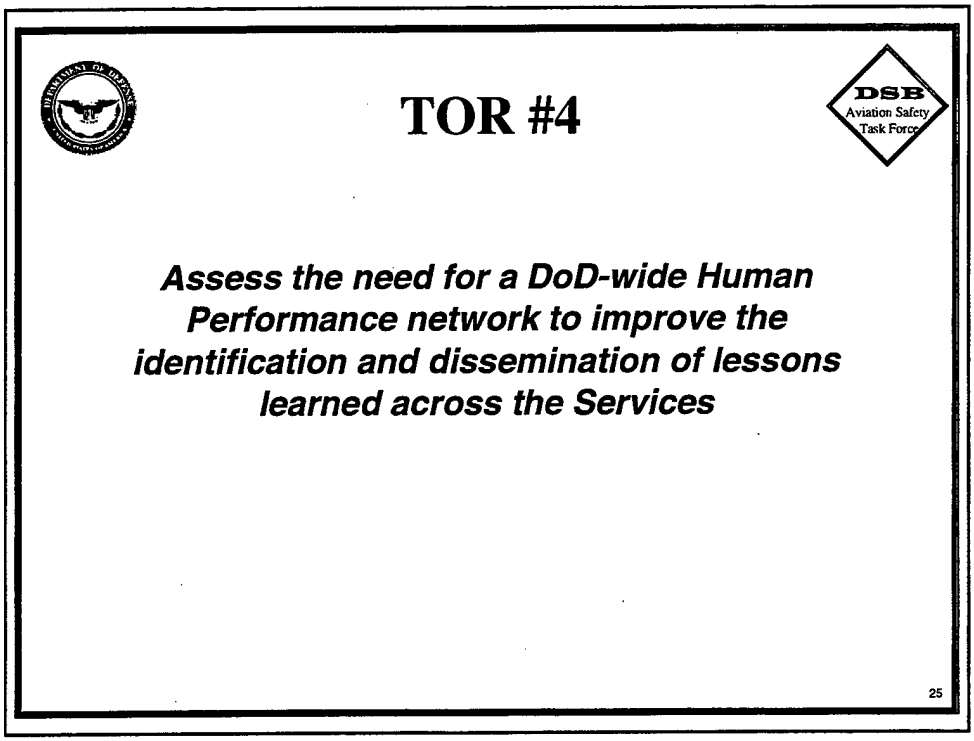


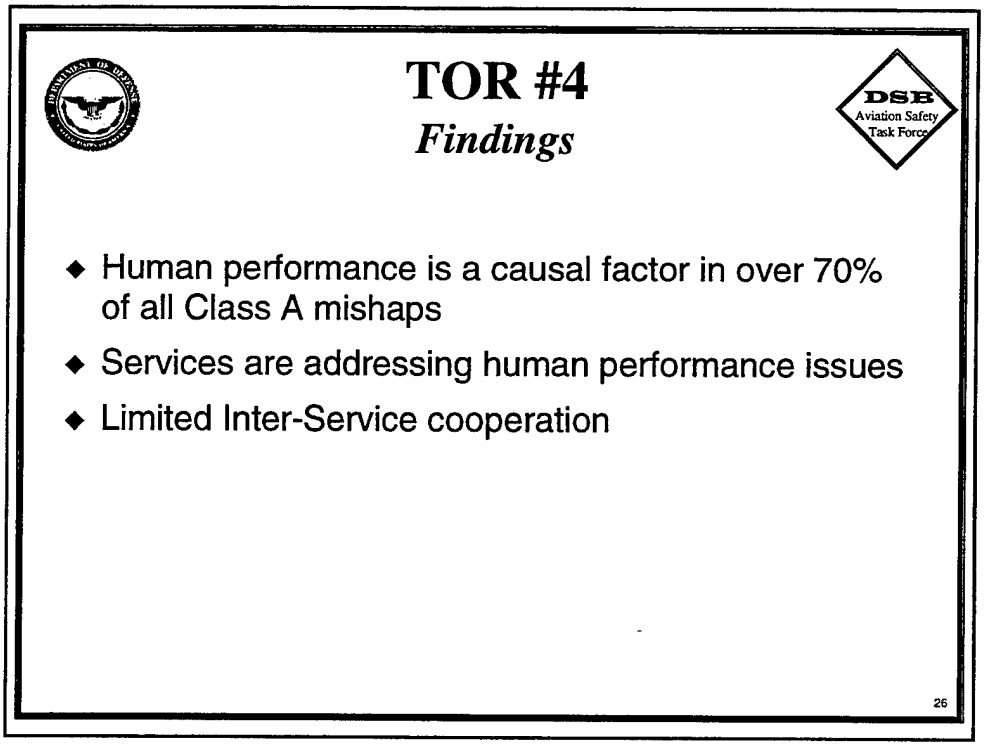
Fully exploit the new opportunities afforded by flight data recorders to collect performance and hardware maintenance data. Acquired pilot and maintenance personnel performance data should be used to assure compliance with established procedures, to modify and improve these procedures, to improve training procedures, and to improve man/machine interfaces. Hardware performance data should be used in a conditional hardware maintenance strategy that would indicate when aircraft components needed replacement. This would reduce the number of components that would be replaced solely based on the number of flight hours or days of operation. It is expected that this will reduce maintenance costs as well as prevent premature hardware failures.



The Services should develop jointly a common information architecture that would facilitate the exchange and analysis of the data. Each Service, however, should collect and maintain control over its own data. Within each Service, the flight data acquisition and analysis system should be developed jointly by the Safety, Maintenance, and Acquisition elements such that each element will benefit from the collected data and information. It is expected that this will reduce the cost and maximize the benefits of the data.

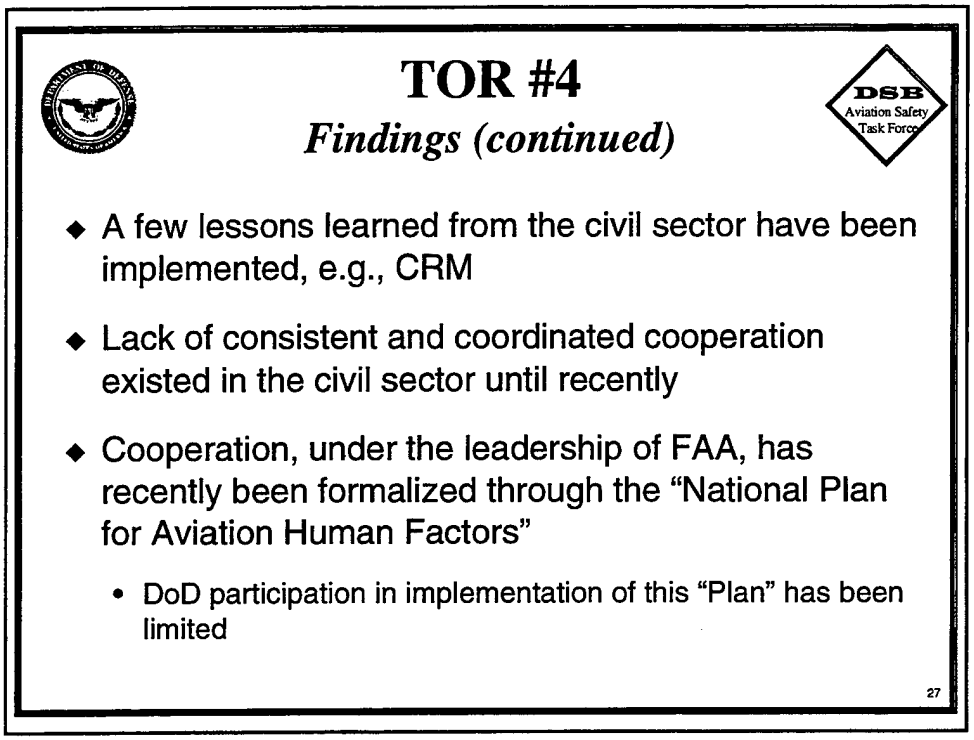
It is the Task Force's opinion that adopting a goal of zero accidents is appropriate. This will require implementation of a "Risk Management" culture where safety is an integral part of a leader's responsibility. Such a change in mindset from the previous practice of accepting an "acceptable" loss rate or hoping for a percent improvement has lead the Army to significant reductions of losses.


TOR #4
DSB
Aviation Safety
Task Force
Assess the need for a DoD-wide Human Performance network to improve the identification and dissemination of lessons learned across the Services
25

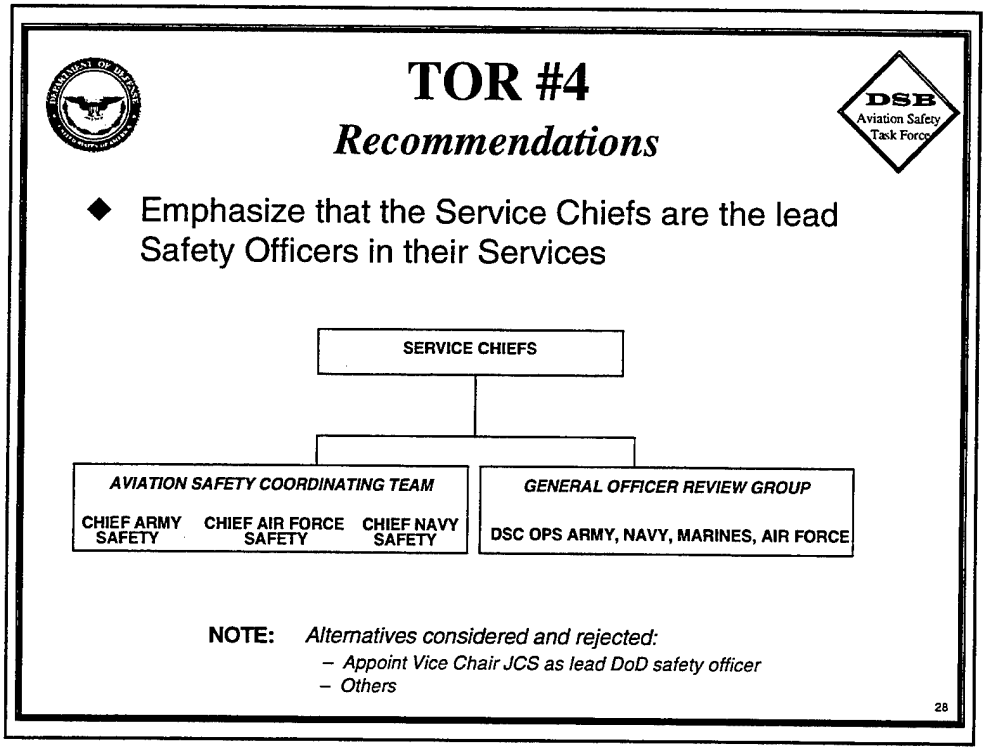


The Task Force found that wide-spread concern exists throughout the Services regarding the human performance elements which have been identified as causal factors in over 70% of all Class A mishaps. Each Service has in place, or is planning, programs to address many of these issues. In many cases individual Services have sponsored and led innovative state-of-the-art efforts to address human performance issues, many of which have come to light as highly automated systems are put into operation. These efforts are somewhat fragmented. For the most part, they are being pursued independently by the respective Services as each tries to identify and address what is perceived as its most pressing human performance issues. Each of the Services pointed out the "uniqueness" of its respective mission and the associated unique aspects of the many "human performance" problems it faced.

The Task Force acknowledged that each of the Services does indeed face human performance issues, some of which are unique. However, the Task Force agreed that sufficient evidence exists to suggest problems related to human performance, in many cases, may have similar root causes and, therefore, may be responsive to common corrective strategies.



The Task Force noted that, at one time, a similar situation existed in civil aviation but that recent efforts to bring about fundamental change have met with some success. Now civil aviation, through a cooperative effort by the Federal Aviation Administration, NASA, the academic community, major labor organizations, and industry, have designed and are implementing the National Plan for Aviation Human Factors. This Plan is designed to formalize and implement a national agenda and cooperative effort to identify, address and ultimately implement solutions to these problems through collective efforts by all interested and capable parties. In addition, FAA, acting in its safety advocacy and oversight role, has recently received and is implementing recommendations which will further formalize national coordinated efforts to focus on human performance issues in aviation. Participation in this effort by the Department of Defense has occurred but has been inconsistent.

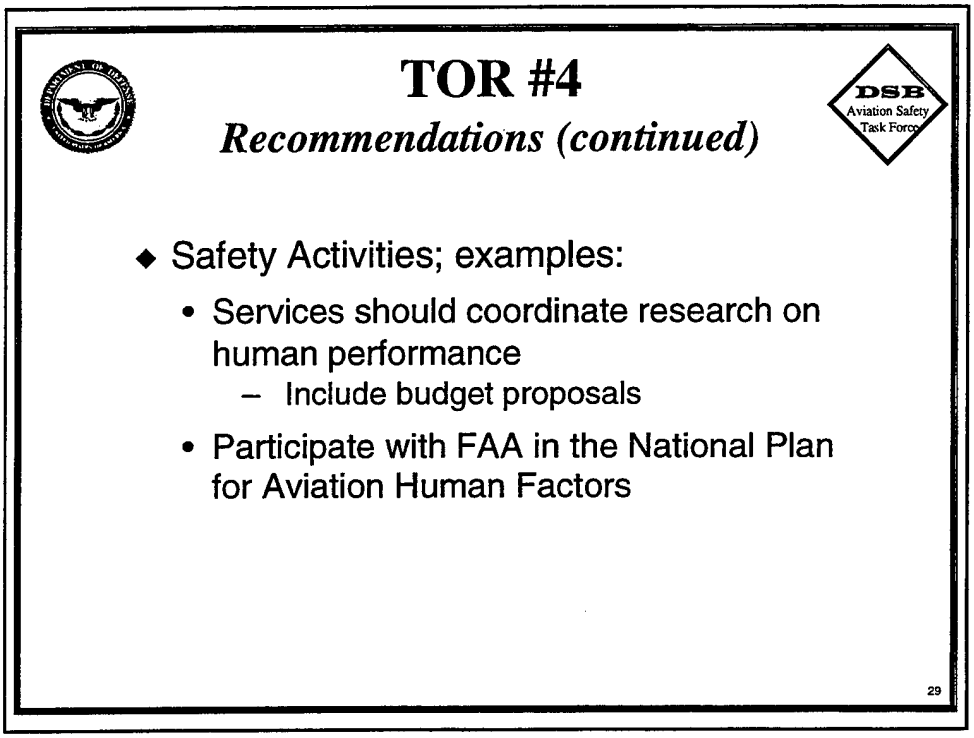


Establish a high level "Safety Team" to coordinate efforts to improve the safety of aviation in the Department of Defense through improvements in human performance. It is further recommended that the Safety Team be made up of the Service Safety Chiefs with oversight provided by a General Officer Review Group. This group should be made up of the Deputy Service Chiefs of Staff for Plans and Operations, who should be briefed twice per year on safety progress, initiatives, and problems.

Appoint the Vice Chairman JCS as the Chief Aviation Safety Officer of the DoD. The Service Chiefs should host a yearly meeting of the Safety Team with the Vice Chairman of the JCS. To raise the level of safety awareness to the highest levels of the DoD, it is recommended that the Vice Chairman of the JCS brief the Deputy Secretary of Defense on safety goals, performance, and initiatives on a yearly basis.

The Safety Team should:

- Institutionalize a formal means of collecting and distributing data throughout the Department of Defense and, when appropriate, other interested civilian organizations, on incidents and accidents, with particular attention to causal factors and lessons learned.
- Develop necessary processes to ensure that human performance information and research products are readily applied to acquisition, certification, regulatory, and operational activities.
- Establish yearly "goals" designed to reduce or eliminate certain types of human performance errors or safety problems and implement programs to accomplish them.

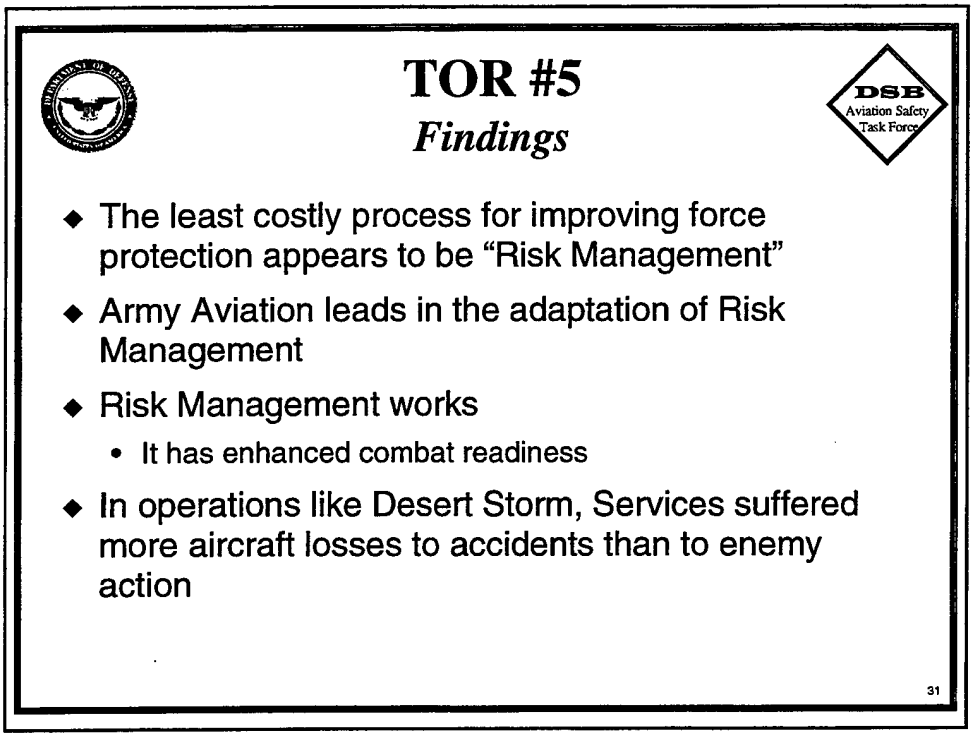


- Coordinate research on human performance within the Department of Defense and with other government and civil agencies in order to avoid unnecessary duplication of effort and capitalize on work already accomplished and lessons already learned.
- Participate with FAA in the implementation of the National Plan for Aviation Human Factors.
- Develop a coordinated budget proposal to support DoD human performance research and development.

TOR #5

Recommend new approaches to institutionalize Risk Management within the Services

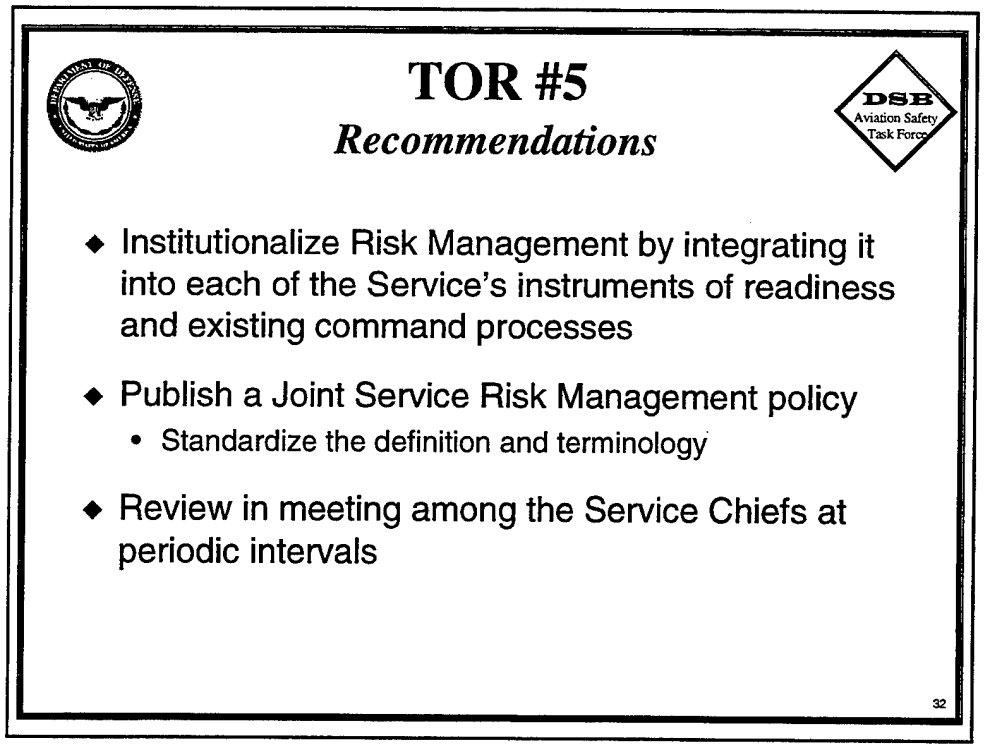
30



The most innovative and least costly process for improving force protection appears to be "Risk Management." It is a process of identifying and controlling hazards to protect the force. Its five steps represent a logical thought process from which users develop tools, techniques, and procedures for applying Risk Management in their areas of responsibility. It is a closed-loop process that's usable on any mission, any time, any place, and by anyone. The five steps are: (1) identify hazards, (2) assess hazards, (3) develop controls and make risk decision, (4) implement controls, and (5) supervise and evaluate.

The Services are recruiting and retaining the finest quality Service members ever. They are more easily trained and they retain what they have learned longer. It is generally accepted that this quality force has become a more safety conscious force. And, indeed the statistics support that premise. The Services' Class A aviation accident trends have been downward over the last twenty years with substantial progress in the last ten years. However, the Task Force observes that the trend line has reached a plateau and new approaches will be required to improve performance.

Moreover, the Task Force observed some troubling trends. Historically, the Services have generally suffered more losses to aircraft accidents than to enemy action while deployed in combat theaters. Typically, these accidents are the same types experienced in training at home station and at combat training centers. The second troubling trend is that, deployed or not, human error is the primary cause or a contributing factor in over 70 percent of accidents.



Each of the Services appear to have embraced the concept of Risk Management. Naval Publication 1, "Naval Warfare" signed by the Commandment of the Marine Corps and the Chief of Naval Operations on 28 March 1994, identify Risk Management and risk assessment as formal, essential tools for operational planning. Air Force Instruction 91-213, dated 1 November 1996, entitled "Operational Risk Management Program" applies to all Air Force personnel and functional areas, including the Air Force Reserve and Air National Guards. The Army introduced the program in 1987 and has made substantial progress with Risk Management during the past two years. In fact, both were record setting years with Class A aviation rates of less than one mishap per 100,000 flying hours.

The Task Force recommends that DoD institutionalize Risk Management by integrating it into each Service's instruments of readiness and existing command process. Failure to integrate it into policy, doctrine, training, leader development, organizational structure, materiel acquisition, and personnel systems will jeopardize the life of the process. We believe this requires that DoD publish a Risk Management policy. DoD should standardize the definition and terminology so as to facilitate the sharing of experiences between the Services.

This Task Force believes that Risk Management is the best approach for changing some troubling trends. Since human error was present in over 70 percent of all aviation accidents, Risk Management will identify hazards and minimize the chance of underestimating the risk or overestimating our abilities to cope. Although each of the Services has embraced the concept, other than the Army, the programs are in their infancy. And indeed the Army has substantial work remaining to fully implement the process across the force. However, results are impressive. During four test rotations at the Combat Training Centers by the Army, substantial reductions were realized in both ground and air mishaps. The Navy/Marines experienced similar results during the December - March 1995 deployment of the USS Eisenhower. Also, Risk Management feedback from Bosnia has been most impressive.

TOR #6

Provide recommendations concerning flight safety technologies that should be installed on each type of aircraft

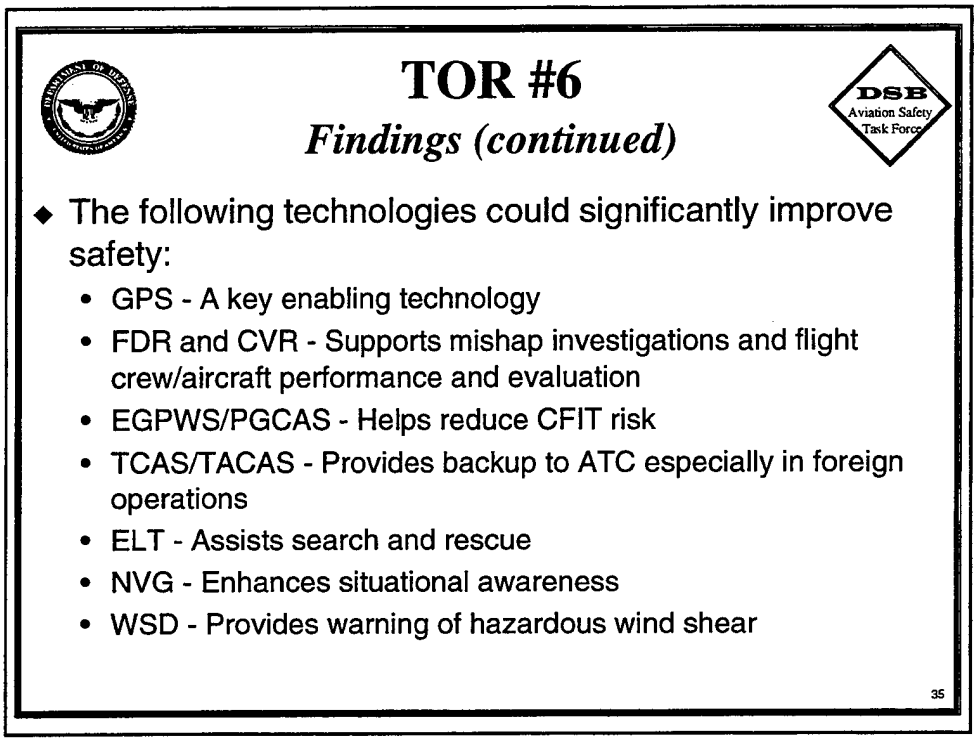
33

TOR #6

Findings

- Technology affords several means to achieve a breakthrough in aviation safety performance
- DoD personnel often fly DoD aircraft equipped with safety technology less than that afforded civil sector passengers
- The Services have provided the Task Force with lists of safety priorities
- The Task Force has consolidated and prioritized these technologies

34



The Task Force considered various military and civil flight safety technologies and found that some are enabling technologies, others act to directly prevent mishaps, and a third type facilitates flight monitoring and post mishap analysis. The Task Force found the following systems to be effective in significantly reducing the risks of Class A Mishaps:

- GPS is a key enabling technology that provides precise location world-wide.
- FDRs and CVRs provide valuable flight data monitoring of the aircraft condition and crew communications. These systems can not only be used for mishap investigation but also afford opportunities in crew performance monitoring and event driven maintenance data collections.
- Enhanced GPWS uses GPS data and a digital data base to increase crew situational awareness of terrain through graphical displays and predictive alerts. These systems have significant value for all aircraft and especially during operations overseas where ATC and radar facilities are inadequate or unavailable. Predictive GCAS is especially useful in preventing G-Induced Loss of Consciousness and Spatial Disorientation CFIT.
- TCAS I and II are providing both safety benefits and flight efficiency benefits. This new technology is now operational on more than 10,000 civil passenger aircraft and this number will increase to 16,000 by 2001.
- ELTs greatly assist Search and Rescue and if provided with GPS position, will dramatically reduce search time.
- Night vision goggles can greatly enhance situational awareness and significantly reduce the risk of low level night operations.
- Wind Shear Detection Systems may provide warning of hazardous wind shear and assist flight crews in escape procedures.

TOR #6

Recommendations

DSB Aviation Safety Task Force

	FIGHTER	BOMBER	AIRLIFT	ROTARY ATTACK	ROTARY PASSENGER	TRAINER
GPS	1	1	1	1	1	1
GPWS/GCAS*	2	2	2	2	2	2
OASYS**				3	3	
FDR/CVS	3	3	3	4***	4***	3
TCAS		4	4	5	5	4
NIGHT VISION				6	6	
ELT	4	5	5	7	7	5
WSD	5	6	6	8	8	6

*GROUND COLLISION AVOIDANCE SYSTEMS
**OBJECT AVOIDANCE SYSTEMS (E.G., WIRE, POLES, ETC.)
***INCLUDING HEALTH AND USAGE MONITORING SYSTEMS

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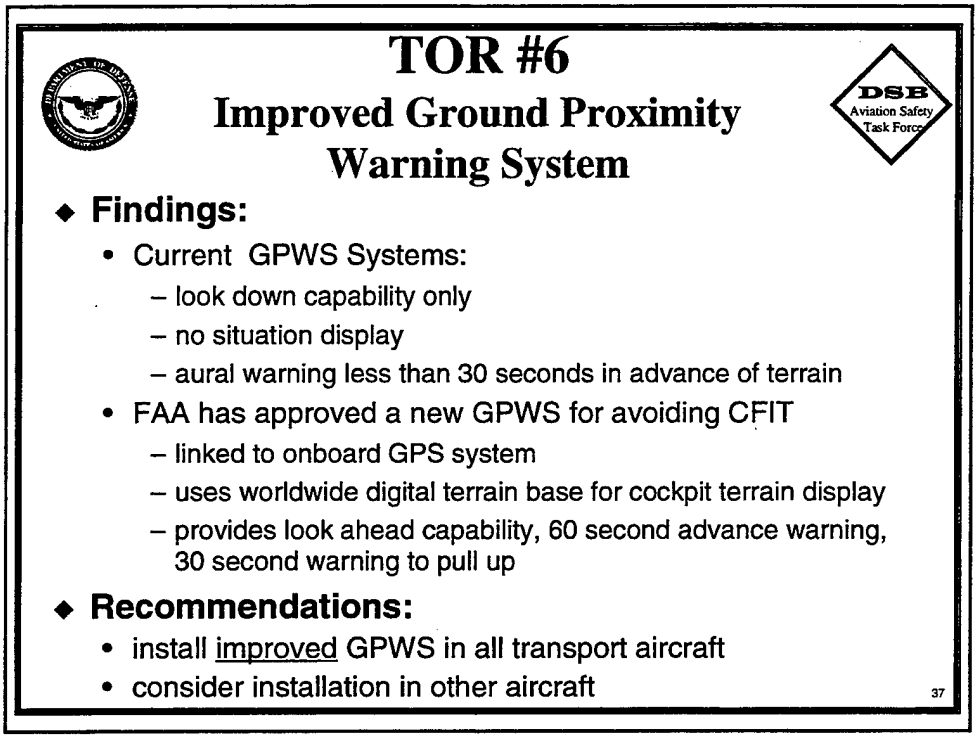
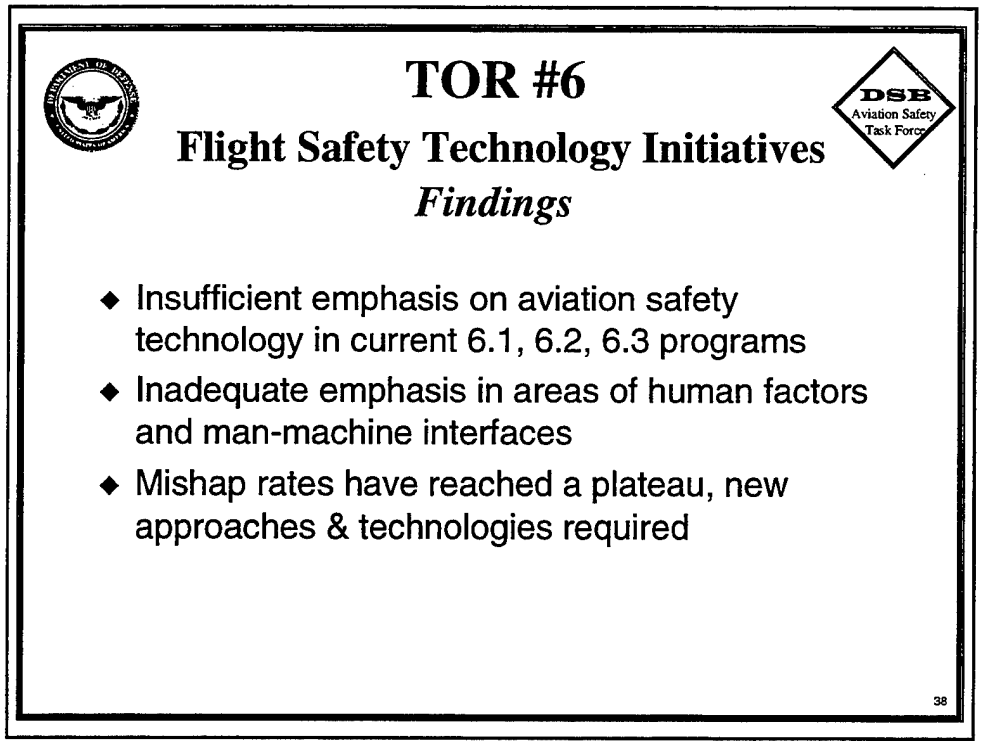
The recommendations in response to the tasking to prioritize flight safety technologies for each type of aircraft in terms of the most cost effective impact on risk reduction are shown above. They are based on consideration of the FY96 Secretary of Defense Directive for GPS and FDRs, the information prepared by the Services, and a broad-based Task Force assessment of the cost effectiveness and impact of flight safety technologies on risk reduction (which was discussed in detail earlier in the report.)

These recommendations represent a merge of the specific recommendations of the Services with the Task Force broad-based assessment and prioritization of flight safety technologies. The Task Force ranked flight data recorders higher than the Services, consistent with the recommendation made under TOR #3 to fully exploit new opportunities afforded by flight data recorders to collect and process crew performance and maintenance data. It is further recommended that consideration be given to the technologies submitted by the individual Services which are unique to their roles and missions.



A powerful new ground proximity warning system has been developed as a commercial product which provides significant advantages over existing systems. The FAA has recently approved the use of this commercial product as an improved system for avoiding controlled flight into terrain. The system, which is linked to the onboard GPS system, makes use of a digital terrain database to provide a cockpit display for look ahead capability and a cautionary advisory 60 seconds in advance of terrain. By contrast, existing systems only have look down capability, do not provide a situation awareness display, provide less than 30 seconds of warning, and have limited or inadequate warning when flying in extremely steep terrain.

In recognition of the fact that controlled flight into terrain remains a major contributor to Class A mishaps, the Task Force recommends that the improved GPWS be installed on all transport aircraft. It is also recommended that the DoD consider the new commercially available improved GPWS for other aircraft.



As stated earlier, current mishap statistics have reached a plateau and new approaches and technologies will be required to break the current trends and significantly improve safety for the Services. It is noteworthy that current DoD 6.1, 6.2, 6.3 science and technology plans do not specifically address aviation safety as an R&D topic or as a target application area. However, several emerging technologies offer significant promise for improvements in aviation safety and risk reduction:

Several emerging technologies offer promise for safety improvements:

- Ground collision avoidance systems are under development which provide predictive automated recovery by taking control of the aircraft if the pilot does not respond appropriately or in time to warnings. These systems provide the capability to avoid controlled flight into terrain and G-induced loss of consciousness mishaps.

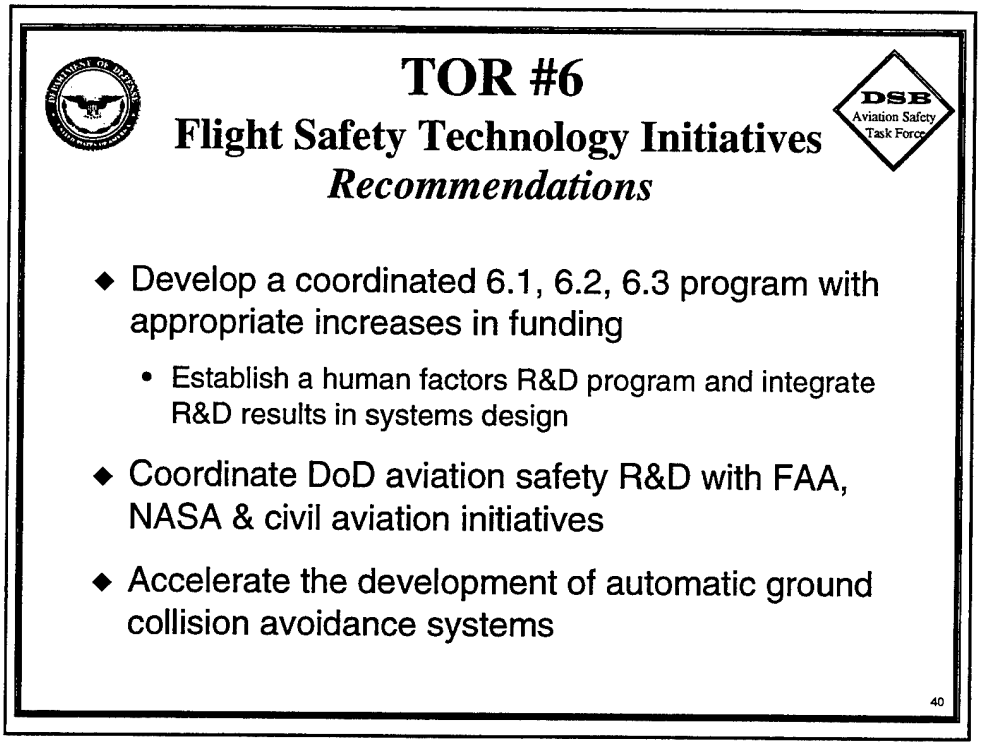
- An industry standards group is developing system requirements for cockpit video recorders which are expected to offer significant advantages for accident investigation and safety training. The recorded information could provide insights into crew performance human factor issues and become a valuable training aid.

- Simulators are a proven approach to improving human performance. Virtual reality technology is being used in telemedicine and training and may offer an alternative to full-motion flight simulators for allowing pilots to experience spatial disorientation and loss of situation awareness.

- Advanced night vision technology, based on charge coupled device technology, is being developed which offers the advantage of improved contrast and digital readout of the scene observed by the pilot.

- A Joint Advanced Health and Usage Monitoring System (JAHUMs) for helicopters is being developed as an advanced concept demonstration to show improvements in safety and reliability, life cycle cost, and operational availability.

In addition, significant aviation safety R&D programs are underway at NASA, FAA and in commercial airline companies.

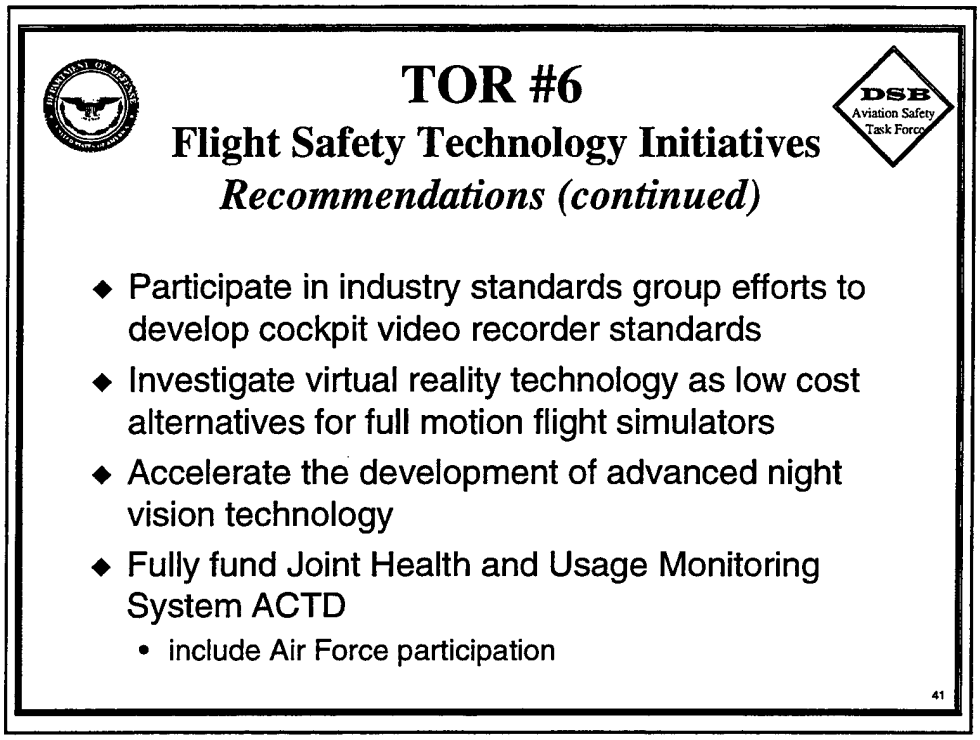


DDR&E and the Services should review current 6.1, 6.2, and 6.3 programs and develop a coordinated R&D plan focused on future aviation technologies and procedures. Increased funding should be allocated for support of these programs.

Particular focus should be given to the area of human factors to better understand human behavior under the stress and workload of the cockpit, to improve the human interface to increasingly complex avionics systems, and to integrate human factors into all phases of system design.

A joint working group should be established to coordinate and leverage DoD Aviation Safety R&D with NASA, FAA, commercial airlines and industry COTS safety equipment developments.

Accelerate the development, test and evaluation of a predictive automatic ground collision avoidance systems which take control of the aircraft when the pilot does not appropriately respond to warnings, thus reducing controlled flight into terrain (CFIT) and G-induced loss of consciousness (GLOC) mishaps.



Actively participate in industry standards group efforts to develop system requirements for cockpit video recorders for use in Risk Management and accident investigations.

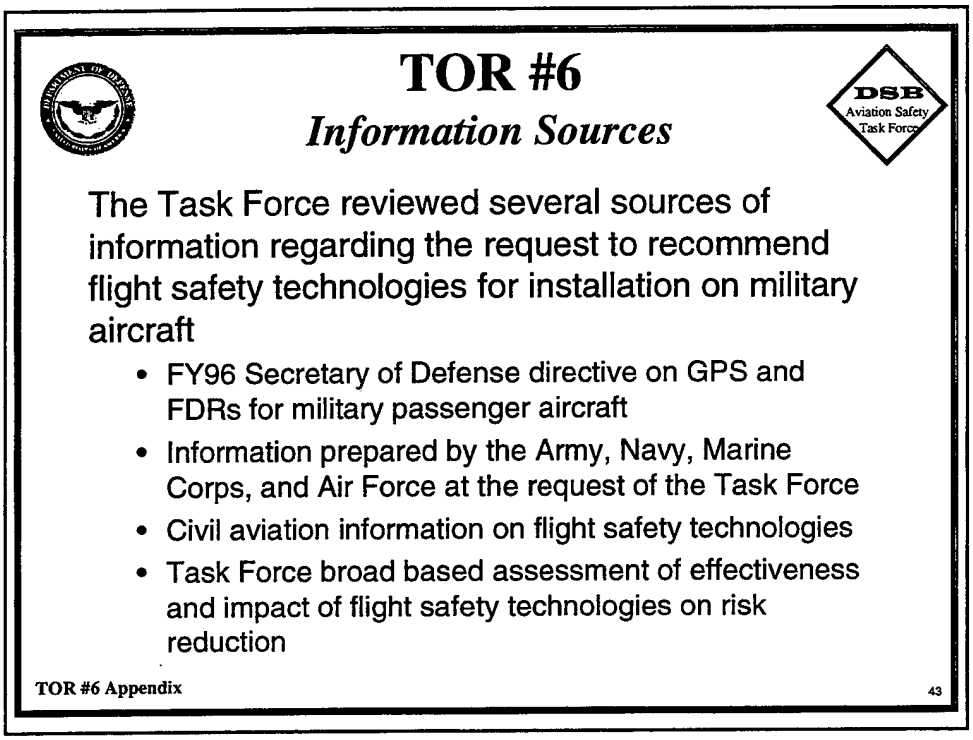
Investigate virtual reality technologies for applications in low-cost, high-fidelity aviation simulators to recreate spatial disorientation, loss of situational awareness, night vision, and other hazardous scenarios.

Accelerate the development of advanced night vision systems based on low light level charge coupled device and thermal imager technology, which provide significant improvements in sensitivity, contrast, blooming suppression and the ability to digitally read out and record the scene observed by the pilot.

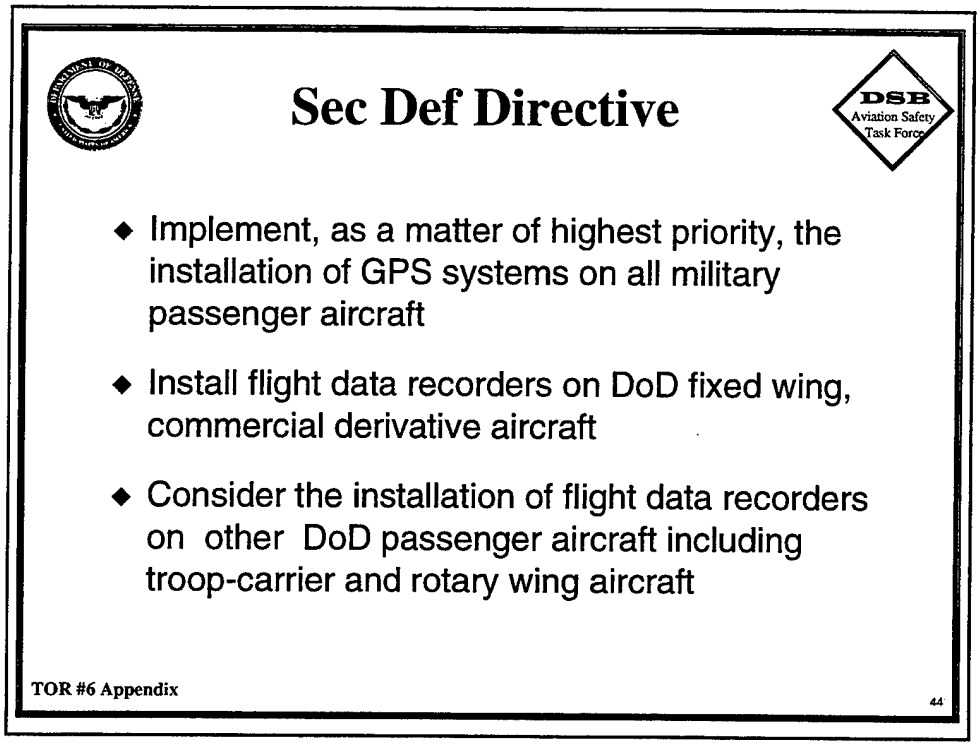
Fully fund and support the JAHUMS ACTD and consider expanding the effort to include Air Force participation in the demonstration program.

TOR #6
Appendix

42

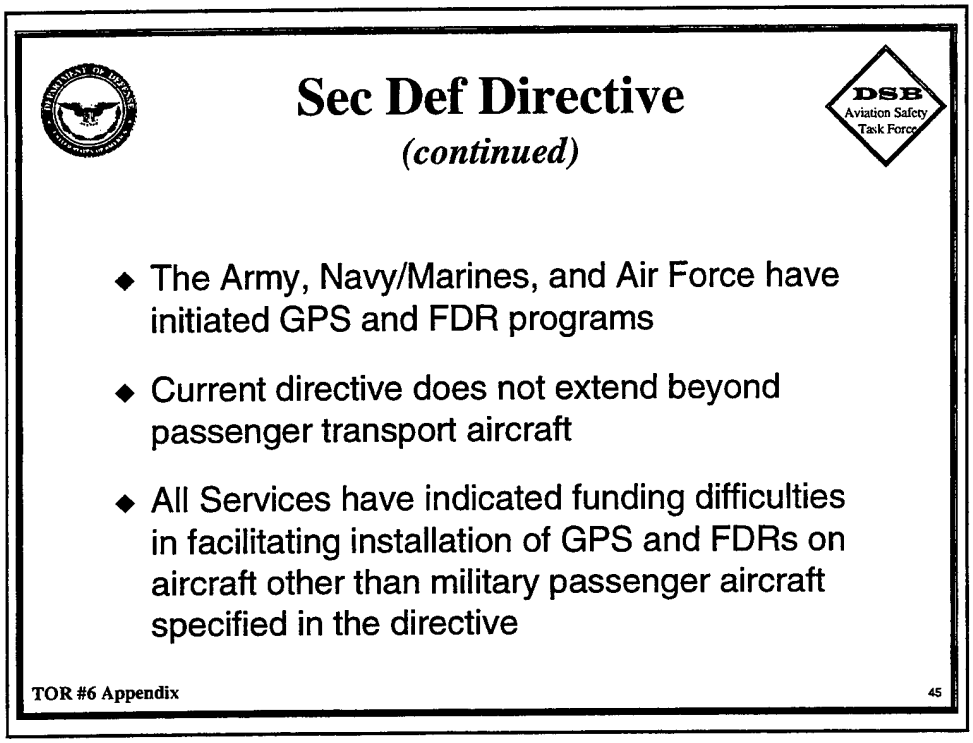


To respond to the tasking to recommend and prioritize safety technologies that should be installed on military aircraft, the Task Force reviewed several sources of information. Particular attention was given to the Service responses to the FY96 Secretary of Defense memorandum directing the installation of Global Positioning Systems and Flight Data Recorders on Military Passenger Aircraft. The Task Force requested and carefully reviewed information from each of the Services on Aviation Safety Technology prioritization. To provide a basis for comparison with military priorities, the Task Force reviewed information on civil aviation safety technologies. In addition, a broad based assessment was made of the effectiveness of various flight safety technologies in reducing risk.



In FY96 the Secretary of Defense provided the following direction to the Services on Global Positioning Systems and Flight Data Recorder Equipment:

"You should implement, as a matter of highest priority, the installation of GPS systems for flight safety on all military passenger aircraft. As the next priority, you should install flight data recorders on your fixed-wing commercial-derivative aircraft. Finally, you should consider the installation of flight data recorders on your other passenger aircraft, including troop-carrier and rotary wing aircraft."



Each of the Services has initiated programs in response to the Secretary's directive. The Air Force has provided guidance for interim GPS systems on all applicable aircraft, for navigation and safety upgrades for the 89th Airlift Wing, distinguished visitor and operational support airlift aircraft, and for the acceleration of GPS installation on other passenger aircraft.

The Army response has been to field integrated GPS on all fixed wing aircraft by FY99, and on other aircraft by the end of FY00, and make every effort to accelerate equipping passenger-carrying aircraft with a combination of integrated or stand-alone GPS receivers. In addition, the Army has initiated a program to install flight data recorders on 19 aircraft at Fort Rucker to explore the uses of data provided by the FDR.

The Navy/Marine response has been to install GPS, cockpit voice recorders, and flight incident recorders on executive airlift and passenger carriers as soon as possible.

The Task Force strongly endorses these initiatives and further believes that the installation of flight data recorders will provide new data sources for engine and aircraft performance that will provide unique opportunities for improving maintenance and risk reduction and for pilot performance evaluation and training.

All Services have funding shortfalls for installation of GPS on other than military passenger aircraft and for installation of flight data recorders. (See slides 37-39 for details.)

Army Aviation Response to Sec Def Directive

DSB Aviation Safety Task Force

- GPS
  - GPS programs are in compliance with April, 1996 Sec Def directive
  - UH-1 unfunded $3.412M
- FDR
  - Demo programs in place, complete in FY98
  - AH-64D maintenance data recorder programs in place
  - Unfunded

152 fixed wing	$ 17.93M
2338 rotary wing	72.00M
	89.93M

TOR #6 Appendix

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Navy/Marine Aviation Response to Sec Def Directive

DSB Aviation Safety Task Force

- Can meet Sec Def/OPNAV tasking with:
  - Relief from congressional language regarding obligation of FY97 funds
  - Maximized COTS / NDI solution

Air Force Aviation Response To Sec Def Directive

- Interim GPS - installation complete 28 Feb 97
- Navigation/Safety equipment Phase I (funded):
  - Install GPS, FDR/CVR, ELT, TCAS, and GPWS on DV/89th OSA and GPS on other passenger-carrying aircraft
  - All programs started NLT 3QFY98; complete FY01
  - Approximately 10% currently completed
- Phase II (unfunded)
  - Install FDR/CVR, ELT, TCAS, and GPWS on other passenger-carrying aircraft

TOR #6 Appendix

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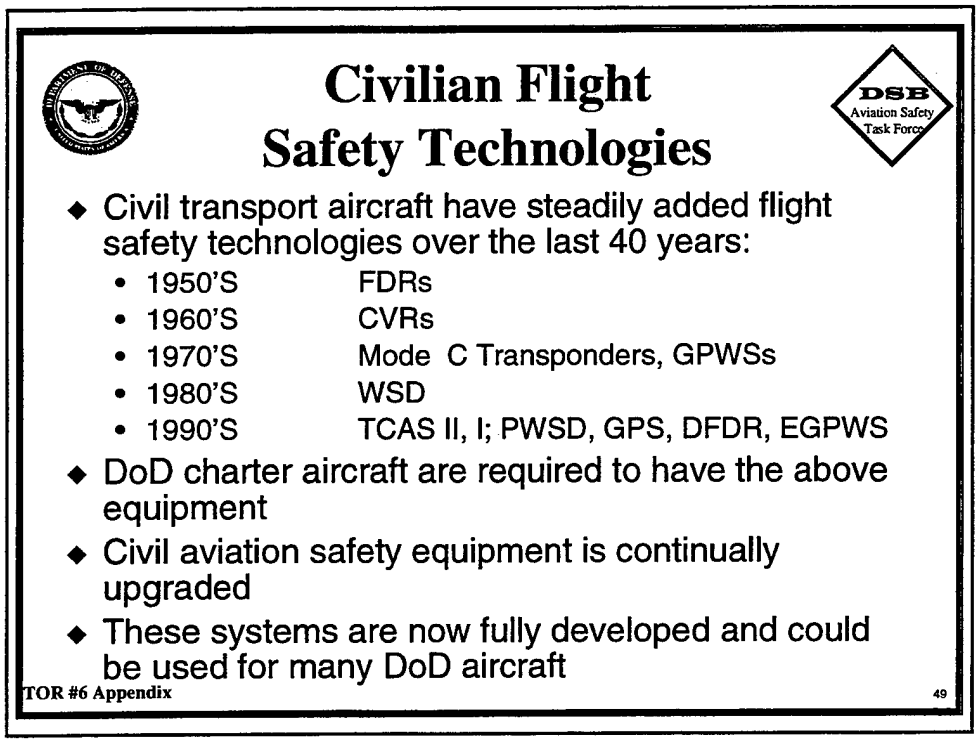
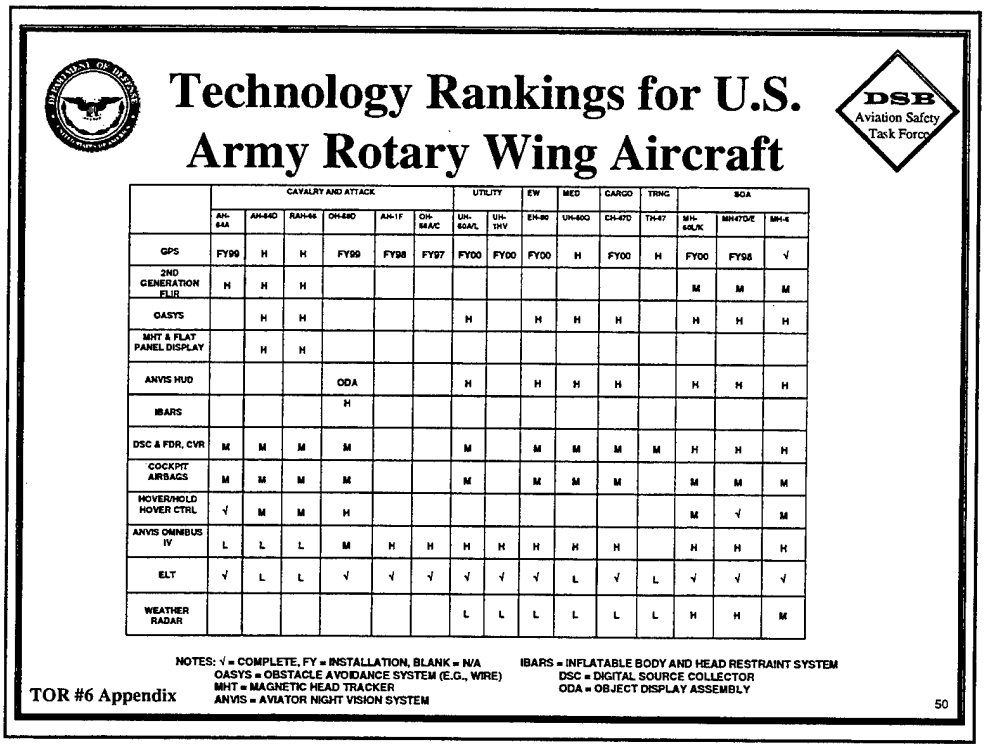


The Task Force reviewed civil aviation safety technologies that may be appropriate in reducing military Class A Mishap rates. It was noted that civil transport category aircraft have steadily invested in flight safety technology during the last forty years and that safety equipment is continuously upgraded. The major safety equipments installed during this time were:

FDRs	1950s
CVRs	1960s
Mode C Transponders, GPWS	1970s
WSD	1980s
TCAS I, II, PWSD, GPS, DFDR, EGPWS	1990s

All of these systems are fully developed for a wide variety of civil aircraft and can easily be configured for installation in military passenger aircraft. Civil aviation aircraft used for DoD charters are required to have the above equipment.

Some systems such as TCAS are providing civil transport aircraft with additional flight efficiency benefits such as TCAS assisted altitude changes during oceanic flights. Also, many civil flight crews are reporting that they now heavily depend on TCAS when flying in Asia and other countries with less capable ATC services.



Technology Rankings for U.S. Army Rotary Wing Aircraft

DSB Aviation Safety Task Force

	CAVALRY AND ATTACK						UTILITY		EW	MED	CARGO	TRNG	SOA		
	AH-64A	AH-64D	RAH-66	OH-58D	AH-1F	OH-58A/C	UH-60A/L	UH-1H/V	EH-60	UH-60Q	CH-47D	TH-67	MH-60L/K	MH47D/E	MH-6
GPS	FY99	H	H	FY99	FY98	FY97	FY00	FY00	FY00	H	FY00	H	FY00	FY98	√
2ND GENERATION FLIR	H	H	H										M	M	M
OASYS		H	H				H		H	H	H		H	H	H
MHT & FLAT PANEL DISPLAY		H	H												
ANVIS HUD				ODA			H		H	H	H		H	H	H
IBARS				H											
DSC & FDR, CVR	M	M	M	M			M		M	M	M	M	H	H	H
COCKPIT AIRBAGS	M	M	M	M			M		M	M	M		M	M	M
HOVER/HOLD HOVER CTRL	√	M	M	H									M	√	M
ANVIS OMNIBUS IV	L	L	L	M	H	H	H	H	H	H	H		H	H	H
ELT	√	L	L	√	√	√	√	√	√	L	√	L	√	√	√
WEATHER RADAR							L	L	L	L	L	L	H	H	M

NOTES: √ = COMPLETE, FY = INSTALLATION, BLANK = N/A
OASYS = OBSTACLE AVOIDANCE SYSTEM (E.G., WIRE)
MHT = MAGNETIC HEAD TRACKER
ANVIS = AVIATOR NIGHT VISION SYSTEM
IBARS = INFLATABLE BODY AND HEAD RESTRAINT SYSTEM
DSC = DIGITAL SOURCE COLLECTOR
ODA = OBJECT DISPLAY ASSEMBLY

TOR #6 Appendix

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The Task Force requested that each of the Services provide recommendations for flight safety equipment for each type of aircraft and to prioritize in order of most cost effective risk reduction

The Army approach to prioritization of aviation technologies was divided between two major categories, fixed and rotary wing aircraft, with some overlap and with significant differences in the suite of technologies listed for each category. For each technology a ranking of high, medium, or low was assigned and in several cases a notation was added to indicate installation of the technology has been completed for the indicated aircraft. A number of areas were common to both categories such as: GPS, flight data recorders (specified as digital source collections and engine health and usage monitoring systems for helicopters) and emergency locator transmitters. However, a significant subset of technologies are unique to helicopters: improved aviator night vision systems, night vision heads-up display, inflatable body and head restraint systems, obstacle avoidance systems (e.g., wire), second generation FLIR, and cockpit airbags.

Technology Rankings for U.S. Army Fixed Wing Aircraft

DSB Aviation Safety Task Force

	SHORT RANGE UTILITY C-12	MEDIUM RANGE UTILITY UC-35	LONG RANGE UTILITY C-20	UTILITY C-26	UTILITY C-21	UTILITY UV-18	CARGO C-23	SEMA RC-12	PARACHUTE TEAM C-31	PARACHUTE TEAM UV-20	NTPS U-21
GPS	√	√	FY97	√	FY97		FY96	FY97			√
CVR	L	√	√	√	FY97		√	L			
FDR	FY96*	√	√	√	FY97		√	FY98*			
GPAAS**	√	√	H	H			√	√			
WINDSHEAR PROTECTION	L	L	L	L			L	L			
TCAS	M	√	M	M	M		M	M			
ELT	√	√	√	√	√	√	√	√	√	√	√
WEATHER RADAR	√	√	√	√	√		√	√	√		√
LIGHTNING SENSOR SYSTEM	√	√	H	H	H		H	H			
FIVE POINT HARNESS	L	L	L	L	L		L	L			

NOTES: √ = COMPLETE, FY = INSTALLATION, BLANK = N/A

TOR #6 Appendix

*AUTOMATED ENGINE TREND MONITORING SYSTEM
** GROUND PROXIMITY ALTITUDE ALERT SYSTEM

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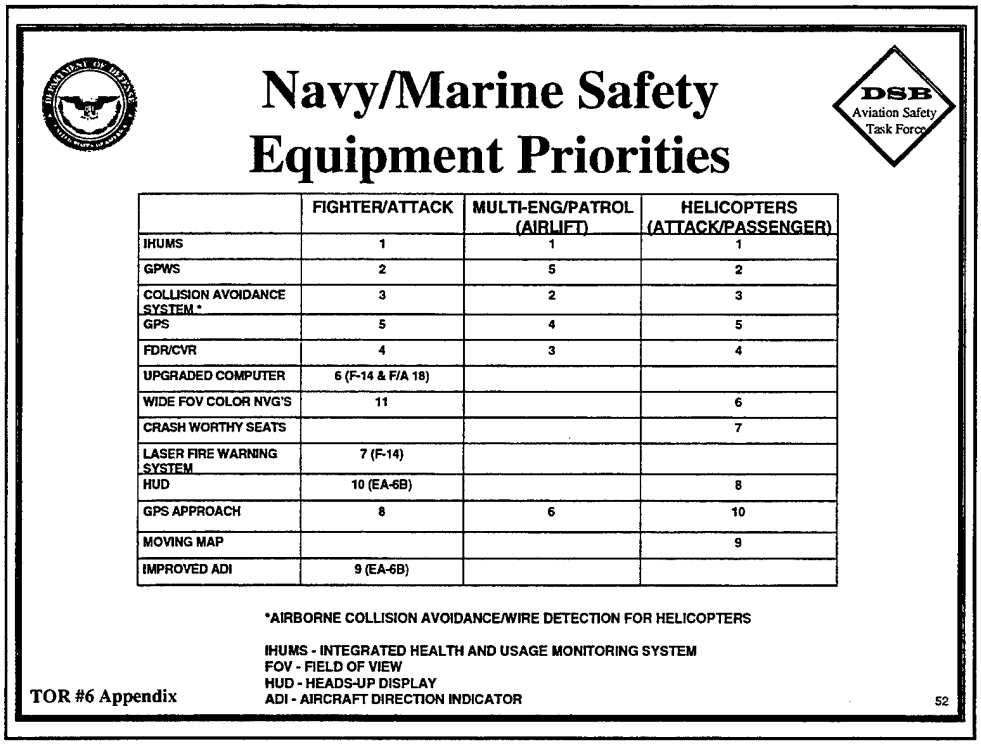
Separate technologies listed for fixed wing aircraft included wind shear protection, ground proximity warning systems, traffic alert and collision avoidance systems, weather radars and lightning sensor systems.



Navy/Marine Safety Equipment Priorities

DSB Aviation Safety Task Force

	FIGHTER/ATTACK	MULTI-ENG/PATROL (AIRLIFT)	HELICOPTERS (ATTACK/PASSENGER)
IHUMS	1	1	1
GPWS	2	5	2
COLLISION AVOIDANCE SYSTEM *	3	2	3
GPS	5	4	5
FDR/CVR	4	3	4
UPGRADED COMPUTER	6 (F-14 & F/A 18)		
WIDE FOV COLOR NVG'S	11		6
CRASH WORTHY SEATS			7
LASER FIRE WARNING SYSTEM	7 (F-14)		
HUD	10 (EA-6B)		8
GPS APPROACH	8	6	10
MOVING MAP			9
IMPROVED ADI	9 (EA-6B)		

*AIRBORNE COLLISION AVOIDANCE/WIRE DETECTION FOR HELICOPTERS

IHUMS - INTEGRATED HEALTH AND USAGE MONITORING SYSTEM
FOV - FIELD OF VIEW
HUD - HEADS-UP DISPLAY
ADI - AIRCRAFT DIRECTION INDICATOR

TOR #6 Appendix

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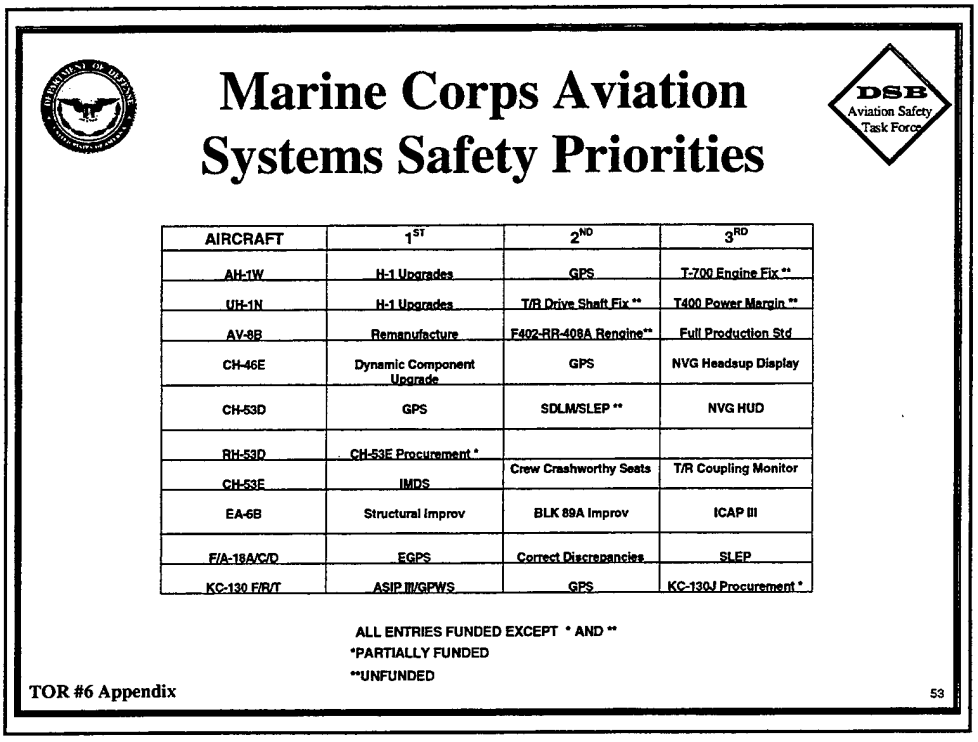
The Navy/Marines approach to setting priorities was focused on three general classes of aircraft: fighter/attack, multi-engine patrol (including airlift), and helicopters. A high priority was placed on integrated health and usage monitoring systems which are in an early stage of development. A high priority was also set for airborne collision avoidance systems and obstacle avoidance systems (e.g., wire detection for helicopters).

A relatively high priority was also set for wide field of view color night vision goggles for helicopters. A number of recommendations were made for specific aircraft, such as upgraded computers for F-14s and F/A 18s, laser-based fire detection systems for F-14s, heads up displays and improved aircraft direction indicators for EA-6Bs, and moving map (situation awareness) systems for helicopters.



Marine Corps Aviation Systems Safety Priorities

DSB Aviation Safety Task Force

AIRCRAFT	1ST	2ND	3RD
AH-1W	H-1 Upgrades	GPS	T-700 Engine Fix **
UH-1N	H-1 Upgrades	T/R Drive Shaft Fix **	T400 Power Margin **
AV-8B	Remanufacture	F402-RR-408A Rengine**	Full Production Std
CH-46E	Dynamic Component Upgrade	GPS	NVG Headsup Display
CH-53D	GPS	SDLM/SLEP **	NVG HUD
RH-53D	CH-53E Procurement *		
CH-53E	IMDS	Crew Crashworthy Seats	T/R Coupling Monitor
EA-6B	Structural Improv	BLK 89A Improv	ICAP III
F/A-18A/C/D	EGPS	Correct Discrepancies	SLEP
KC-130 F/R/T	ASIP III/GPWS	GPS	KC-130J Procurement *

ALL ENTRIES FUNDED EXCEPT * AND **
*PARTIALLY FUNDED
**UNFUNDED

TOR #6 Appendix

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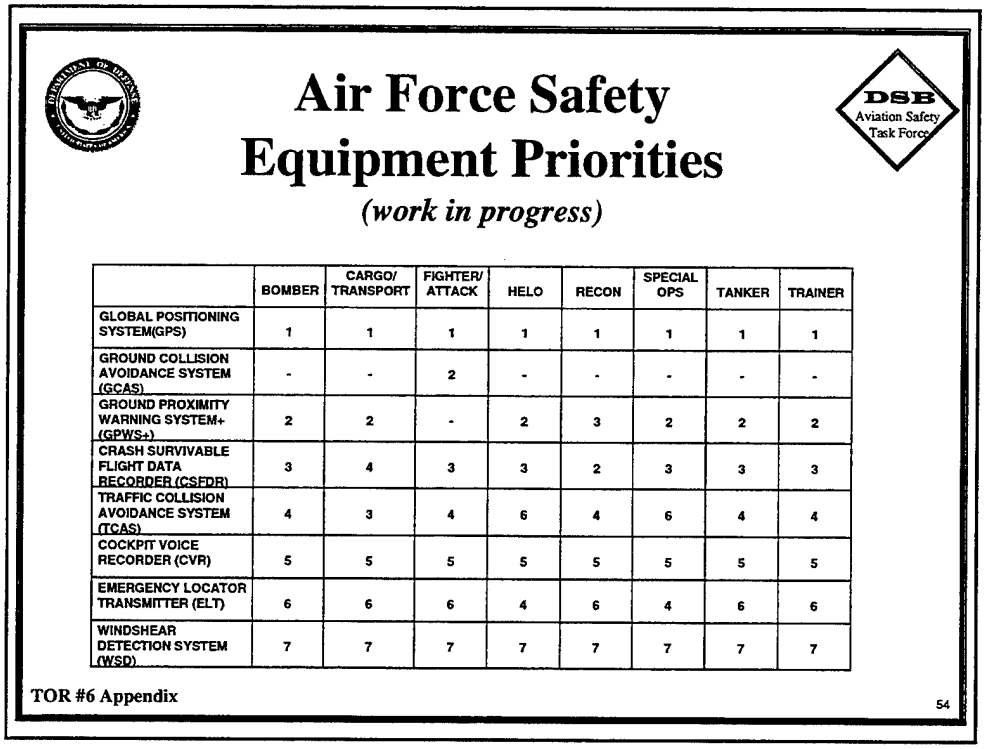
The Marine Corps approach to ranking aviation safety systems priorities was to identify the top three priorities for both fixed and rotary wing aircraft. Some form of GPS was listed in five of the ten aircraft included in the list. A night vision goggles heads-up display was also specified for the CH-53R and CH-46E. An integrated mechanical diagnostic system was also included as a first priority for the CH-53. A ground proximity warning system was included as part of KC-130 aviation systems improvement program. Flight data recorders were not listed as one of the top three priorities for any of the listed aircraft.



Air Force Safety Equipment Priorities

(work in progress)

DSB Aviation Safety Task Force

	BOMBER	CARGO/ TRANSPORT	FIGHTER/ ATTACK	HELO	RECON	SPECIAL OPS	TANKER	TRAINER
GLOBAL POSITIONING SYSTEM(GPS)	1	1	1	1	1	1	1	1
GROUND COLLISION AVOIDANCE SYSTEM (GCAS)	-	-	2	-	-	-	-	-
GROUND PROXIMITY WARNING SYSTEM+ (GPWS+)	2	2	-	2	3	2	2	2
CRASH SURVIVABLE FLIGHT DATA RECORDER (CSFDR)	3	4	3	3	2	3	3	3
TRAFFIC COLLISION AVOIDANCE SYSTEM (TCAS)	4	3	4	6	4	6	4	4
COCKPIT VOICE RECORDER (CVR)	5	5	5	5	5	5	5	5
EMERGENCY LOCATOR TRANSMITTER (ELT)	6	6	6	4	6	4	6	6
WINDSHEAR DETECTION SYSTEM (WSD)	7	7	7	7	7	7	7	7

TOR #6 Appendix

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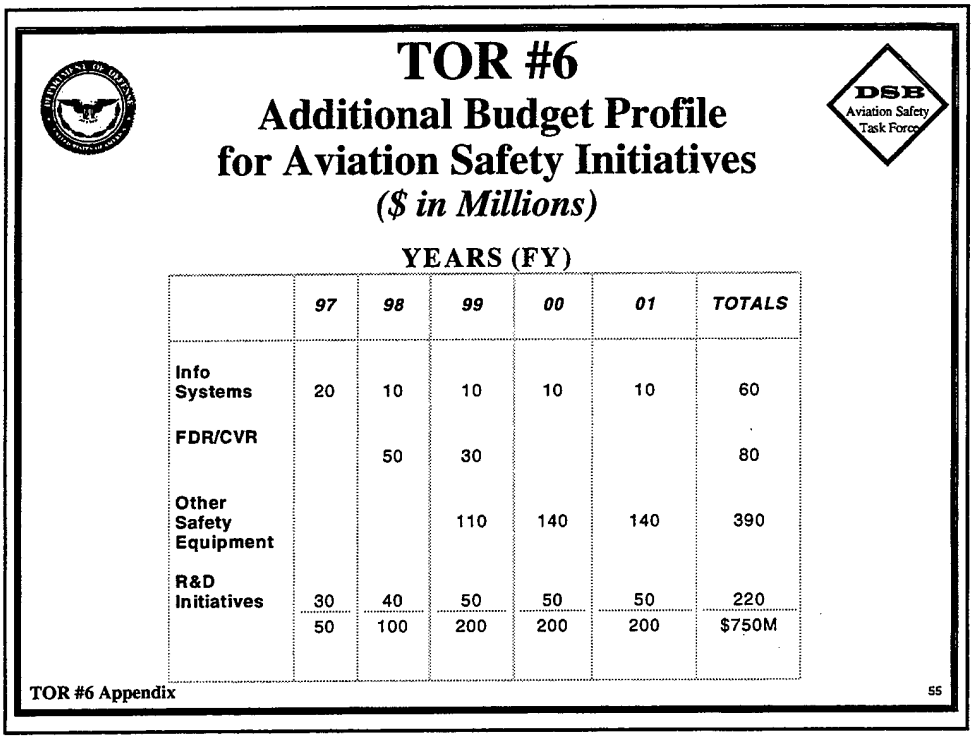
The Air Force provided their summary of priorities as shown in the figure above and noted that it was work in progress. Their approach was to statistically examine their mishap database, to document and validate currently installed or planned safety equipment, and then to prioritize equipment for each type of aircraft based on mishap reduction potential. It is worth noting that the Air Force advocates, for all aircraft except fighters, state-of-the-art ground proximity warning equipment, which provides advanced warning of impending terrain hazards. For fighters, the recommendation is to install ground collision avoidance systems that can take control of the aircraft if the pilot does not respond appropriately to warnings.



TOR #6
Additional Budget Profile for Aviation Safety Initiatives
($ in Millions)

YEARS (FY)

	97	*98*	*99*	*00*	*01*	*TOTALS*
Info Systems	20	10	10	10	10	60
FDR/CVR		50	30			80
Other Safety Equipment			110	140	140	390
R&D Initiatives	30	40	50	50	50	220
	50	100	200	200	200	$750M

DSB Aviation Safety Task Force

TOR #6 Appendix

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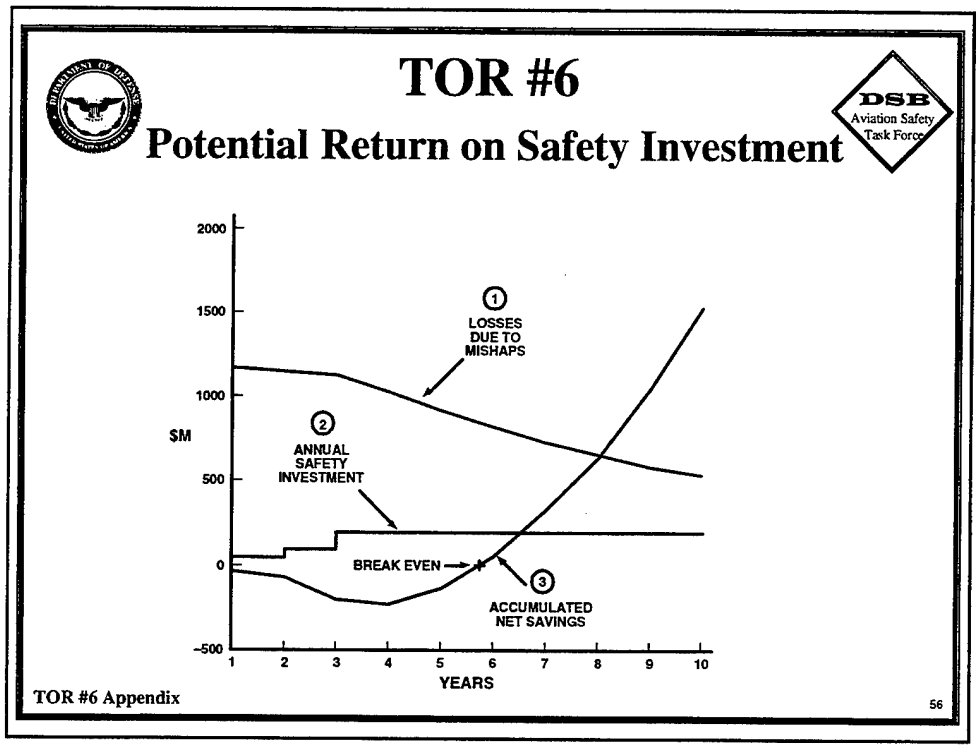
This chart is included to illustrate a suggested investment strategy for aviation safety initiatives.

The following chart describes a cost model that projects the possible dollar return on investment from such a budget profile.

Note how rapidly the accumulated net savings rise in the out-years. In addition to preserving lives and readiness, safety investments also can generate large cost avoidance.



Accumulated Years Savings	Status Quo Mishap Loss	Safety Inv. Mishap Loss	Annual Savings	Annual Safety Investment	Annual Net Savings	Net
1	1200	1175	25	50	-25	-25
2	1200	1150	50	100	-50	-75
3	1200	1125	75	200	-125	-200
4	1200	1013	187	200	-13	-213
5	1200	911	289	200	89	-124
6	1200	820	380	200	180	56
7	1200	738	462	200	262	318
8	1200	664	536	200	336	654
9	1200	598	602	200	402	1056
10	1200	538	662	200	462	1518
TOTALS	12,000	8732	3268	1750		1518

Assumptions: 1. Status Quo Mishap Costs remain stable at 1200K per year in year 1 dollars

2. Years 1-3 spent deploying equipment, developing CVR/FDR data analysis systems, and institutionalizing Risk Management.

3. Years 4-10 realize 10% Annual Average Reduction in Mishap Rate due to continued safety investments.

Note: Dollars in Millions

Acronym List

ATC	Air Traffic Control
ATS	Attrition Trade Study
CBA	Cost Benefit Analysis
CFIT	Controlled Flight Into Terrain
COTS	Commercial Off-the-Shelf
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DV	Distinguished Visitor
EGCWS	Enhanced Ground Collision Warning System
EGPWS	Enhanced Ground Proximity Warning System
ELT	Emergency Locator Transmitter
FDR	Flight Data Recorder

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Acronym List

(continued)

FLIR	Forward Looking Infra-red Radar
GLOC	G-Induced Loss of Consciousness
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
JCS	Joint Chiefs of Staff
JAHUMS	Joint Advanced Health and Usage Monitoring System
NDI	Non-Developmental Item
NLT	Not Later Than
NVG	Night Vision Goggles
OSA	Operational Support Aircraft
OSD	Office of the Secretary of Defense
PGCAS	Predictive Ground Collision Avoidance System
PWSD	Predictive Wind Shear Detection
TCAS/TACAS	Traffic Alert and Collision Avoidance System
TOR	Terms of Reference
WSD	Wind Shear Detection

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